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REVISION OF THE PALÆOCRINOIDEA.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

INTRODUCTION.

According to Miller's catalogue of American paleozoic fossils, there have been described, in this country alone, up to the summer of 1877, about 800 species of Crinoids, not including Blastoids and Cystideans. If we add to this number some 400 species from Europe —an estimate which is certainly not exaggerated when we remember that Schultze described from the Devonian of the Eifel alone 73 species; DeKoninck and Le Hon from Belgium 45; and Angelin from the Silurian of Sweden 176—we have from both countries about 1250 species. Making due allowance for synonyms, we have possibly 1000 good species, which are distributed among from 150 to 175 genera. Many of the latter were established at a time when our knowledge of the Crinoids was in its infancy. They were frequently founded upon one or two species, often, indeed, on a single imperfect specimen; which resulted in many defective, insufficient, and not unfrequently incorrect descriptions, producing endless perplexing complications afterwards.

There was a time when nearly every fossil Crinoid was *Encrinites.* This was the case almost until 1821, when J. S. Miller described his well-known genera *Poteriocrinus*, *Actinocrinus*, *Platycrinus*, *Rhodocrinus*, and *Cyathocrinus*, which have been universally adopted by the later paleontologists—with the exception, perhaps, of *Cyathocrinus*, which was badly defined by him. As new species were discovered, the founding of additional genera progressed, and generic distinctions came to be recognized between groups of forms, which substantially agreed in the arrangement of the plates of the body, but differed in the anal plates, the construction of the arms, and other characters to which but little attention had before been paid. Through such separations it resulted in many cases that the parental genus was divided up into a number of genera, and it finally became evident that some of the features which had been considered of mere generic importance, were family characters. The majority of the genera thus established have been adopted by most of our leading paleontologists, but by some entirely ignored. It is a singular fact that European authors have commonly refused to accept our genera of *Actinocrinidæ*, while they sustained those of the *Cyathocrinidæ*, which are certainly no better defined. This is doubtless due to the fact that in Europe the *Actinocrinidæ* do not abound in such wonderful variety as in this country. If our European brethren had to deal with nearly 300 species, as we have, they would perhaps be more ready to accept our divisions.

As early as 1842 T. Austin and T. Austin, Jr. (Rec. & Foss. Crinoidea), undertook to subdivide the Crinoidea into families, but they were not very successful, as they placed together types of very distinct groups. Roemer (Lethæa Geognostica, 1855, 3d Ausgabe) made another attempt in the same direction. He was the first author who pointed out correctly the relations of the Blastoids and Cystideans with the true Crinoids; and, if he was not so fortunate in establishing his families, we must consider how imperfectly Crinoids were known at that time. Some of Roemer's family names are still in use, but scarcely two of our present authors interpret them alike.

The late Prof. Angelin[1] divided the Silurian Crinoids of Sweden into four sections: *Trimera*, *Tetramera*, *Pentamera*, and *Polymera.* A subdivision according to the number of basal plates may facilitate elementary studies, but it is certainly not a natural classification. Genera which are evidently intimately related—for instance, *Platycrinus* and *Dichocrinus*, *Melocrinus* and *Rhodocrinus*—are thereby widely separated, while very distinct types, such as *Rhodocrinus* and *Poteriocrinus*, are brought together. Angelin arranged his 40 genera of Swedish Crinoids under 23 families; but, as he gave no diagnoses of them, we are at a loss to know upon what principle his families were established.

In the second part of an article on the "Internal and External Structure of Paleozoic Crinoids," by Chas. Wachsmuth, published in the August and September numbers of the Amer. Journ. Sci., 1877, one of the writers gave a minute description of the summit or ventral disk of the earlier Crinoids, and reached the conclusion that the construction of the vault affords good characters for a separation into families. He distinguished three principal plans —though he admitted the existence of a number of others—upon which the summit is constructed:—

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[1] In the *Iconographia Crinoideorum in stratis Sueciæ Siluricis fossilium, auctore N. P. Angelin*, opus posthumum edendum curavit Regia Academia Sueciæ, cum tabulis XXIX. This is one of the finest illustrated works on Crinoids that has ever been published, and it must be regarded as a great loss to science that the distinguished author died before the completion of his work.

1. The summit composed of a more or less pliable, sometimes perhaps squamous, integument, yielding to motion in the body and arms.

2. The summit composed of solid plates with a porous ventral sac, located posteriorly on the disc, and closed at the top. Anal opening rarely observed, but probably lateral.

3. The summit composed of heavy immovable plates, closely joining and forming a dome arching the entire oral side. Anal opening directly through the wall of the dome or at the extremity of a tube, the so-called proboscis.

We have since given this subject our special attention, and find that these diversities in the construction of the ventral portion of the body bear a striking relation to the general arrangement of the plates of the dorsal side; that the parental genera to which we have referred have each their own peculiar summit structure, and that the genera into which they were subsequently subdivided are characterized by mere differentiations of the original plan. We find that *Ichthyocrinus* and its congeners, *Taxocrinus*, *Mespilocrinus*, etc., which are embraced in almost the same generic formula, possess summit structure No. 1; that in *Cyathocrinus*, *Poteriocrinus*, *Heterocrinus*, and all genera with five basals, five subradials, and five radials, the summit structure agrees with No. 2; and that the *Actinocrinidæ*, *Platycrinidæ*, and *Rhodocrinidæ*, with their numerous genera, are constructed like No. 3. We consider that the last three groups are subdivisions of one great group, and propose to introduce them hereafter as subfamilies. These three, or, as we may say, five families thus indicated, include more than one-half of all known paleozoic Crinoids. The others we leave for future consideration.

The absence of an external oral aperture is most remarkable in the anatomy of the earlier Crinoids. The actinostome, or oral centre, is situated beneath the vault, and forms the radial centre of a peculiar skeleton of tubular passages which connect with the arms. These passages beneath the vault are evidently homologous with the food grooves and ambulacral canals at the peristome of recent Crinoids, the vault being thus a mere covering or protection. That the mouth was internal in the majority, if not all paleozoic Crinoids, as well as all the Cystideans and Blastoids, is very significant, and impresses us most forcibly with the idea that the earlier Crinoids form a distinct group, and that the solid covering may have been essential under the conditions that prevailed in paleozoic times.

The genus *Lichinocrinus*, which Hall describes from the Lower Silurian of Cincinnati, affords an instructive example in this respect. In this interesting form, the oral or ventral side was always attached to a shell, coral or other foreign substance; the dorsal side has a long stem, but whether this was attached to the bottom or not, is not known. The oral side, when found detached, which is of very rare occurrence, shows a large number of striæ, which converge to a very small opening in the centre. According to our interpretation, this opening is the mouth, the striæ the food passages, and the shell to which the ventral side is attached, takes the place of the vault, which is as yet undeveloped.

Another very characteristic distinction between ancient and recent Crinoids is to be found in the comparatively large size and massive body plates in the fossil, contrasted with the diminutive body and very long and highly developed arms of recent types; and the same is even more strikingly true as to Blastoids and Cystideans. To illustrate, we might say that in the *Pentacrinidæ* they are fully developed; that they are in progress of growth in paleozoic Crinoids, and that they are only budding or sprouting in Blastoids and Cystideans; while in *Lichinocrinus*, which is probably still lower in the scale of organization, the arms have not yet made their appearance.

Upon these distinctions, principally, Wachsmuth (Am. Journ. Sci., Sept. 1877, p. 190) proposed to separate the paleozoic from the recent Crinoids, under the name PALÆOCRINOIDEA, as a suborder of the Crinoids, of equal rank with the BLASTOIDEA and CYSTIDEA.

To facilitate a better understanding of the two groups, we now direct attention to certain organs which have been known to exist in Cystideans and Blastoids, and which we think existed in a modified form in the Paleocrinoids. These organs, which were called "hydrospires" by Billings (Am. Journ. Sci., July, 1869, p. 75), occupy rather large spaces within the body in the first-named groups, and this may perhaps explain in a measure the comparatively large size of the calyx in the older Crinoids generally. The hydrospires were located within the perivisceral cavity, connected with the inner floor of the test, and communicated, so far as ascertained, through the test with the outside water. In the Cystideans the hydrospires are of a rhomboidal shape—each rhomb being divided into two triangles by a suture between two of the plates (Pl. 17, Figs. 7, 8.). In *Caryocrinus ornatus*, each of the four sides of the rhombs is bordered by a row of small tubercles (Pl. 17, Fig. 6), some of which have a single pore in the apex, while others are perforated by two to twenty or more. The pores penetrate through the plates, but do not communicate directly with the visceral cavity of the body. Internally, each hydrospire consists of a number of flattened tubes, arranged parallel to each other, and each tube receives two of the pores, one at each end. In a large hydrospire, there are about twenty or more tubes. Whatever may have been the special function of these tubes, naturalists generally agree that they belong to the respiratory system, and we infer from the distribution of the pores in variable numbers at and about the apices of the tubercles, that they very probably served as a madreporic apparatus, through which water for respiration was introduced and expelled. In other genera of the Cystideans, we find in the test one or more striated rhombs with fissures and pores, somewhat resembling the madreporic body of other Echinoderms.

In the Blastoids, there are certain orifices arranged around the actinal pole, which have been called ovarian apertures on account of their supposed resemblance to similar openings in the Ophiurans, but if they were connected with the reproductive organs, which is by no means proved, they evidently had additional important functions. These openings appear in various forms. We find in the earlier types fissures arranged on the upper portion of the body; at a later period slits along each side of the ambulacra, and in the latest and higher types, five pairs of orifices which surround the oral centre. None of these openings communicate with the general cavity of the body, but they all connect with peculiar organs closely resembling the internal tubes of *Caryocrinus*, and which are also called "hydrospires." The hydrospires of the Blastoids, though actually arranged interradially, are located beneath the ambulacra, and occupy the perivisceral cavity, extending laterally for some distance beyond the sinus along the inner side of the forked plate. In most genera, they are constructed upon the same general plan. There are ten sacs (compare Pl. 17, Fig. 5) which do not connect with each other, disposed in pairs, one pair to each ambulacrum, and each pair separated by the lancet piece. Toward the visceral cavity, they are folded into a number of longitudinal plications, which show neither pores nor passages. The inner and outer folds alternate with each other, and are distended at their closed ends. On approaching the apex of the body, they coalesce to form two separate sets of tubes. The tubes from the inner folds are formed by the adhesion of the walls of the outer, and, *vice versa*, so that the folds which open toward the visceral cavity give rise to the outer set of tubes, while those opening in the opposite direction become the inner tubes. The former terminate within coridors leading to the so-called ovarian orifices, those of each two adjoining hydrospires of two different ambulacra terminating in one orifice; while the latter communicate with an annular organ located against the inner wall of the test and surrounding the oral centre. The number of folds varies from three to nine or more. The walls of the sacs, which were evidently composed of fine membranous substance, must have been strengthened by the secretion of calcareous particles, or they would not be found so well preserved; and they were flexible since we find the folds in various degrees of expansion. *In Codaster*, one of the earliest and probably one of the lowest type of the Blastoids, and in *Codonites*, its subcarboniferous representative, there is in place of the folded sacs a large number of tubes placed side by side, and arranged parallel with the external fissures or grooves. This structure of the hydrospires so closely resembles that of some of the Cystideans that Billings proposed to remove *Codaster* from the Blastoids and place it among the Cystideans. This we cannot endorse, but we do agree with him, that whatever may have been the functions of the calycine pores, pectinated rhombs, and internal tubes in the Cystideans, those of the parallel tubes or folded sacs in the Blastoids must have been very similar if not identical.[1]

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[1] We have given above the description of the hydrospires in *Pentremites.* Those of *Granatocrinus* and *Nucleocrinus* vary in some of the details. One of us, who devoted much time to the study of the Blastoids, made a large number of sections of the hydrospires, in different genera, and finds

No such organs have ever been described in the true Crinoids neither from the Palæocrinoidea nor the Pentacrinidæ.

We have given so minute a description of the hydrospires as they occur in the Cystideans and Blastoids, partly because they have been indifferently known, but also in order that we may better compare with them certain organic structures, which we have discovered in some Paleocrinoids, and which we think still further distinguish the latter from recent Crinoids, while at the same time indicating a closer relationship with the Blastoids and Cystideans.

Wachsmuth, in Am. Journ. Sci., Aug. 1877, p. 126, noted a marked difference between the proboscis in the *Actinocrinidæ* and that in the *Cyathocrinidæ*. He considered the former a mere anal tube, or prolongation of the anal opening; but this organ in the *Cyathocrinidæ* he believed to be an essential part of the body, in which the anal opening, here located laterally and low down, is of but secondary importance, and therefore proposed to call it "ventral sac" instead of proboscis. We have since had occasion to examine the ventral sac in several most excellent specimens, particularly with reference to the pores to which he called attention, and have become convinced that these are very probably the homologues of the calycine pores in the Cystideans. The plates of the ventral sac in the *Cyathocrinidæ* are usually comparatively large, rather thin, hexagonal pieces, longitudinally arranged, alternating with those of the adjoining rows. The pores perforate the plate at each angle. It is now very interesting to observe that in some species—for instance, *Poteriocrinus Missouriensis*, Shum. *Pot.* (*Scaphiocrinus*) *unicus* Hall, there are in place of the pores slit-like fissures of considerable length. Four of these fissures—sometimes six—connect with those of the plates of the adjacent row, those of each half of a plate meeting corresponding slits in two different plates, so that one half of the fissures point upward and the other downward. We have filed several of the plates to the very bottom, and have found that the fissures pass entirely through them, and in many cases, where they have been observed, they form longitudinal depressions along the ventral sac, caused by the thinning of the plates toward the fissures. In some species,

that they form excellent generic distinctions. It is really astonishing how beautifully in some instances, these delicate organs have been preserved.

the fissures occur not only at the lateral, but also at the upper and lower sides of the plates, meeting here in like manner with the slits of the adjoining plates. In species in which the plates are provided with three slits to a side, the median one is larger than the other two, thus forming with the corresponding slits of the adjoining plate the figure of a quadrangle or rhomb, divided into two triangles, exactly as Billings describes the parallel canals which compose the hydrospires in *Caryocrinus*. Indeed, the similarity which seems to exist in this respect between the two groups, is so striking, that we can scarcely doubt that both structures were adapted to the performance of the same functions. It is true that the hydrospires in *Caryocrinus* are located on the aboral, and in the *Cyathocrinidæ* on the oral side of the body, but it must be remembered, as already shown (Am. Journ. Sci., Sept. 1877, p. 190) that the entire test of paleozoic Crinoids forms a part of the abactinal system, and the position of the hydrospires in Cystideans is by no means confined to the aboral side, nor to the oral in Paleocrinoids. We find in the genus *Porocrinus*, Billings, which forms a kind of link between Cystideans and Paleocrinoids (the arrangement of the plates of the calyx is exactly like that of all *Cyathocrinidæ*), that the hydrospires are altogether confined to the calyx. In the sutures between the plates, there exist a number of striated, poriferous areas, resembling the pectinated rhombs in their structure, and though their form and position are somewhat different from those of any other known Crinoid or Cystidean, there can be no doubt that they performed in the animal the same office. Unfortunately we do not know whether this genus had a poriferous ventral sac; nor have we been able to ascertain whether the longitudinal depressions on the ventral sac which we have noticed above, were covered—perhaps by perforated plates, such as Billings observed upon the tubercles of *Caryocrinus*—or only the pores and fissures, but we are inclined to think the former was the case, since we found in some other specimens of *P. unicus*, no depressions, but at the same time no fissures nor pores.

In many of the *Actinocrinidæ*, *Platycinidæ*, and *Rhodocrinidæ*, which are provided with a simple anal tube or an anal opening directly through the vault, the respiratory organs were probably located within the main body, at least there are many facts which seem to indicate this. In an article on page 248 of the Proceedings of the Acad. Nat. Sci. Phila., 1878, we noted the existence of certain pores or openings located between the arm bases and separated from the arm passages by a thin partition. Their number varies from ten to twenty or more. In *Batocrinus*, where they are most conspicuous, there are twenty, no matter whether the species has more or less than twenty arms. They are about one-third the size of the arm passages, with which they are in very near the same horizontal plane. There are two pores to each interradial field, one to the left of one arm, and one to the right of another. Ten other pores have a radial position, two within each of the five axillary spaces which form the median portion of the rays. In *Strotocrinus*, which has an enormous body, each arm has a pore, and so in *Steganocrinus*, *Eucladocrinus*, and apparently in all genera in which the arms branch off alternately. Other genera have only ten pores. In *Ollacrinus* the pores are represented by two longitudinal passages through the tubular extensions of the interradial series, or the false arms as usually called.

As these openings, especially in *Batocrinus*, are comparatively large, it is somewhat surprising that they have never been mentioned by other paleontologists. Their position corresponds almost exactly with that of the so-called ovarian apertures of the Blastoids though they are placed at a greater distance from the radial centre. The openings in both groups are situated within the brachial zone or at the extreme border of the summit. In the Blastoids the ventral disc or summit is reduced to the minimum in size, being composed only of the covering of the ventral opening; and this explains why the orifices are here found close to the radial centre, while in the forms above named they are located away from it. The pseudambulacral fields of the Blastoids represent the ventral groove of a recumbent arm, and the small passages which enter the body near the apex and beneath the central covering are the homologues of the arm passages in the true Crinoids. (Compare Pl. 17, Fig. 4.) The so-called ovarian openings are therefore located beside the arms, just as the pores in *Batocrinus*, and this strongly indicates a similarity in their functions.

In addition to this the perivisceral cavity in the *Actinocrinidæ* contains a number of chambers, and, from the brachial zone down to the base, is separated from the visceral cavity by a peculiar partition or network, pierced by innumerable pores and passages leading toward the visceral cavity which contains the digestive apparatus. Whether the above described pores communicated with these chambers cannot be determined from the fossil, but we may perhaps infer this from their position, and also that the chambers themselves were or contained organs similar to those described as hydrospires in other groups of the Crinoidea.

Folded sacs or parallel tubes, as in the Blastoids, have not hitherto been noticed in the Palæocrinoidea. That they existed in some groups of the latter is almost certain. The so-called "consolidating apparatus" of *Cupressocrinus* (Pl. 17, Fig. 3) is in our opinion a true set of hydrospires, arranged in pairs exactly as in Blastoids, but spreading out horizontally instead of vertically. Angelin (Iconogr. Crin., Pl. VIII. Fig. 7, *a*, *b*) figures a *Crotalocrinus*, in which the consolidating apparatus—or hydrospires, as we believe —is most excellently preserved. Even the inner tubes can be traced, and, if there existed still a doubt whether the closely related *Cupressocrinus* had its ventral side firmly closed, Angelin's figure, Pl. VIII. Fig. 6, ought to remove it. There seems to be in *Crotalocrinus* not only a solid integument covering the entire ventral disc and inclosing the hydrospires, but we judge from Fig. 7 of the preceding plate, that the oral centre or median space between the hydrospires had even a double covering.

It seems to us that there can scarcely be a doubt but that the consolidating plates of *Cyathocrinus* (Pl. 17, Fig. 2) are homologous with the oral plates of the Pentacrinoid larva (Pl. 17, Fig. 1), and ought to be designated as such; and further, that the so-called consolidating plates of *Cupressocrinus* are the homologues of the deltoid pieces of the Blastoids (Pl. 17, Fig. 4). It will be seen that all four occupy the same relative position in the respective types. There are five interradial plates, which join at their sides, extending inward, but so as to leave an opening at the oral centre. The affinities, indeed, are so striking that we think it not unreasonable to suppose that the hydrospires are metamorphosed oral plates. The construction of the deltoid pieces is very complicated, only the median or deltoid portion being visible externally. They are extended laterally, in spade-shaped appendages (Pl. 17, Fig. 4), which pass under the ambulacral fields and are hidden by them. To these appendages the folds of the hydrospires are attached, being suspended on each side of the ambulacrum, or modified arm, and partly covered by it. In the so-called consolidating plates of *Cupressocrinus* we find precisely the same structure. Each plate has lateral extensions, each of which supports a set of folds which incline in opposite directions. The number of folds varies in different species, *Cupressocrinus abbreviatus* having apparently seven, and *C. gracilis* but two or three, and so in the Blastoids, *Pentremites pyriformis* has seven folds and *P. Godoni* but five. As the folds of two different plates are not connected laterally, a sort of depression or groove is formed in a radial direction, which evidently contained the food passage, covering the sutures between the plates as the pseudambulacral folds cover those of the deltoid pieces in the Blastoids. The so-called consolidating plates with their folds, of *Cupressocrinus*, and the deltoid pieces with their appended hydrospires in Blastoids, being not only analogous in position but also almost identical in structure, it is very evident that they had a similar office in the animal organism, and that if these organs in Blastoids were respiratory, the hydrospires in *Cupressocrinus* and *Crotalocrinus* had the same functions.

This view of the relations of the parts under consideration suggests a possible analogy in the general structure of Blastoids and Paleocrinoids, in which we may consider that the ambulacrum is a recumbent arm; the lower part of the forked plate up to the ambulacrum is the first radial—in *Blastoidocrinus*, the oldest known Blastoid, the suture is visible—that the two sides of the fork, instead of being interradial, form together a second radial, and the small summit plates are homologous with those which cover the central opening between the oral plates in *Cyathocrinus*, or to the entire vault in the *Actinocrinidæ*, etc., in which the oral plates do not exist—at least not externally. The food groove and ambulacral canal are located upon the pseudambulacral fold, which represents the ventral groove in the arms of the Crinoids, and are likewise covered by two rows of alternating plates. If these homologies be correct, it is evident that there is a much closer relation between Paleocrinoids and Blastoids in fundamental structure than has been heretofore supposed, and as we find in the former the representatives both of parallel tubes and folded sacs, it is evident that their hydrospires are constructed upon a cystidean and blastoidean plan combined.

We have now noticed the principal forms in which these organs have been observed; there are, however, a large number of forms in which no trace of them has as yet been discovered. These include among others the *Ichthyocrinidæ*, and a few genera of the *Actinocrinidæ* and *Cyathocrinidæ*. In the *Ichthyocrinidæ*, respiration may have been carried on through the pliant vault, aided by the expansions and contractions which the flexible nature of the skeleton could produce. In the *Actinocrinidæ*, however, the body, as in the Blastoids, is perfectly rigid, the plates heavy and firmly cemented together. There are no other openings in the body but the anal aperture, the arm passages, a passage through the column and the pores between the arm bases which we have described. In some genera, however, the last-named pores apparently do not exist. The introduction of water through the anal tube need not be considered for a moment, nor through the arms, which in no group of the Echinoderms perform such an office. Let us examine the column.

The construction of the column varies in different genera. It is perforated throughout the centre by a passage connecting with the interior of the body, which in some cases is a simple, small, round opening, while in others it is very large and marked by a peculiarly complicated internal structure. In the latter, the tubular cavity extends to all the branches which spring off rather numerously toward the root. It is mostly pentamerous, though in some cases tri- or quadri-partite ; it is sometimes regularly pentagonal, and sometimes divided into five petaloid chambers which unite at the centre. The walls within appear as if built up of thin laminæ, with spaces between, sometimes pectinated, and variously sculptured, all producing a great multiplication of exposed surfaces. In some the articulating faces of the stem segments are covered with striæ, radiating from the centre, which resemble minute pores penetrating the walls. We have found the very base of one of these large columns just as it was attached to the rock or other flat surface. It is very broad and deeply channelled on the bottom, and there are numerous branches or unattached cyrrhi, all of which are perforated, and through which there was ample communication with the surrounding water. In addition to this, there are large pores near the base of the column, leading from without into the main cavity directly through the walls.

Such an extraordinary structure was not necessary, if the column was merely an attachment or anchor for the Crinoid. That it was a means of communication between the water outside and the internal organs of the body for some purpose we entertain no doubt, and the large amount of surface exposed by means of the complex lamellar structure, is strongly suggestive of the principle which prevails in the respiratory apparatus in the animal kingdom generally. We have said that some *Actinocrinidæ* probably do not possess the pores in the body. It is very significant that it is in these very forms that we find columns such as we have just described. Indeed, in general, so far as we have been able to observe, we have found it to be the rule, that those types which have a perforated ventral sac are without pores in the calyx; that those with calycine pores do not possess a perforated ventral sac, and that in forms with a flexible vault, or with perforated ventral sac, or with pores in the body walls, the column is generally destitute of any such complex structure, and has only a small, simple aperture. There may be exceptions to this; in fact we know of some, but these relate exclusively to very large species, in which the openings in the main body, which we suppose to be respiratory passages, are inadequate to supply the immense body. The most remarkable examples of this kind are *Megistocrinus* and *Barycrinus*. The former, which belongs to the *Actinocrinidæ*, has species with larger bodily capacity than has been discovered in any other genus. It has generally only ten primary arms, and most probably only ten respiratory pores in the body. *Barycrinus* attains by far the greatest size of the *Cyathocrinidæ*, and the column of this genus like that of *Megistocrinus* is not only very strong, but its central cavity is exceedingly large and complicated. We thus have in these two genera apparently another mode of communication from the outside, which may have been either a cause or an effect of their extreme size.

All these facts have led us to suppose that the column was in some cases, and perhaps more or less in the Paleocrinoids generally, subservient to respiration. This supposition would not only account for the complicated structure of the column where it exits, but furnish a plausible explanation as to how the introduction of water was effected in species in which apparently no other openings are present.

With these observations, which we hope will at least be suggestive of some interesting points, and perhaps stimulate more detailed observation, we pass to another matter of considerable importance as bearing upon classification.

Prof. P. Herbert Carpenter, in a valuable paper (Quarterly Journ. Microscop. Sci., vol. xviii (new series), p. 351), on the "Oral and Apical Systems of the Echinoderms," undertakes to determine the homologies between that system of plates in the calcareous skeleton of the Echini known as apical plates, and certain parts of the calyx of Crinoids, both recent and fossil. He considers the basals of recent Crinoids to be homologous to the genital plates, and the radials to the ocular plates of the Echini, and he traces the homology to the Palæocrinoidea, in respect to which, however, he advances the opinion that the first ring of plates resting upon the upper stem segment, which have heretofore been nominated "basals" are in many types not basals at all. He regards the set of plates which lie next below the radials as the true "basals," no matter whether they rest directly upon the stem, as in *Platycrinus*, or are separated from it by another ring of plates, as in *Cyathocrinus;* so that the "subradials" of most American authors, or "parabasals" as they are generally termed in Europe, are "basals" according to his view. The lowest or proximal ring of plates, in types having "subradials," he calls "underbasals," and these he believes to be unrepresented in the other types of Crinoids and all other Echinoderms. The central plate of the apical system, represented by the central disk or subanal plate of the Echini, is thought by Carpenter to be the homologue of the terminal joint at the base of the stem in all pedunculated Crinoids, and in the Pentacrinoid larva of *Comatula*, and of the central plate in *Marsupites.*

In several respects these views conflict with those of A. Agassiz and Lovén, who regard the subanal plate of the Echini as the homologue of the centro-dorsal plate of *Comatula;* and both these as representing the "basals" of the Crinoids, by which term they designate the first ring of plates above the stem in all types. They consider the single plate in the apical system of the Echini as the equivalent of the basalia of the Crinoids metamorphosed into one.

Carpenter's reasoning in regard to the basal plates is, that, as the genitals in the Echini, and the basals in most Paleocrinoids, which are generally considered to be their homologues, are situated *interradially* with regard to the general symmetry of the body, we must expect to find the genitals in Paleocrinoids in the same relative position; and that in forms like *Cyathocrinus*, which have two rings of plates below the radials, the lower or proximal plates are situated in line with the radials, and hence cannot be the true basals. He holds that the same order of plates cannot be radial in one genus and interradial in another. This argument is unquestionably a very strong one, and we are enabled to confirm it by a number of interesting observations.

Let us consider the first ring of plates resting upon the upper stem joint in Crinoids, where it consists of less than five, as a metamorphosed representative of a set of five plates, in which two or more have been united by anchylosis. It will be observed that in nearly all types with but one ring of plates below the radials, *i. e.*, forms without "subradials," the proximal ring is so placed that the angles alternate with those of the radials, so that the whole set, whether five plates or not, may very appropriately be considered as *interradial* with regard to the general structure of the body.

In forms like *Platycrinus*, *Symbathocrinus*, etc., in which the radials rest directly upon a basal disc composed of three unequal plates, if we bisect the two larger, we obtain five equal plates, which occupy an interradial position. This is actually done in *Belemnocrinus*, which in the apical system has the identical structure of *Rhizocrinus*, and most of the recent Crinoids, viz., five basals, interradially situated, supporting five radials.

In *Melocrinus* and *Eucalyptocrinus*, where the proximal ring consists of four plates, we may divide the larger one and thus obtain five plates, which, though not wholly regular in form, are all interradial in position.

In *Actinocrinus* which has three equal plates in the basal disc, and *Dichocrinus* which has two, and allied genera, an apparent difficulty is presented, for if we subdivide these plates we have six basals instead of five. But here the structure is precisely the same in principle as in the foregoing cases. The six plates are interradial in position, and the presence of the anal plate in the same range with the first radials necessitates an additional plate in the basal ring for its support, so that the two plates which support it are equivalent to one. The anal plates are actually nothing more than an interradial series with a special function, viz., the support of the anal apparatus within the body, and of an opening in the vault, which may be either directly through the test, or prolonged into a tube. In some of the *Ichthyocrinidæ*, the anal is not distinguishable from any interradial series. The presence of the anal series as an element in the structure of many Paleocrinoids, may be largely due to the solid dome, which has to be penetrated by a special aperture, requiring some modification of the general structure below to accommodate it. It seems to have no direct representative in the apical system of the recent Echinoderms, but we may be justified in considering it as a specialized interradial, and in that case the basals of the forms under consideration are found to conform entirely to Carpenter's interpretation, being interradially disposed. We find a most interesting confirmation of this view in a specimen of *Actinocrinus* (*Strotocrinus*) *umbrosus*, which has abnormally no first anal plate, the first radials joining at their sides. The anal series in form and proportions is very similar to the other interradials, being chiefly distinguished by having three plates in the second range instead of two, as in the others. Accordingly, we find the basal disc in this specimen reduced to three *unequal* plates, and if we bisect the two larger, we obtain five equal plates, interradially situated, just as in *Platycrinus.* Nature herself, in this isolated specimen, has thus beautifully illustrated our argument. It is well to note in this connection that in *Platycrinus*, and all genera with three unequal plates in the proximal ring, the small plate is never, so far as we have observed, on the anal side, and this is the case with the abnormal specimen above described, the small plate being situated below the suture of the left posterior and lateral rays. *Why* this is so we are as yet unable to explain.

In forms like *Cyathocrinus*, *Rhodocrinus*, etc., which have two rings of five plates each, the proximal plates are radially situated, and, therefore, according to Carpenter, cannot be basals or homologous to the genitals, but the second ring of plates or "subradials," being interradial in position, are the true basals and the homologues of the genitals. If, now, we examine those types with two rings below the radials, in which the proximal ring consists of less than five plates, we shall find his idea still further confirmed.

In the *Ichthyocrinidæ* (except *Calpiocrinus?*) which have in the proximal ring three unequal plates, they are so proportioned and so situated that if we divide them by two additional sutures into five about equal plates, *these five will be radially situated*, and exactly equivalent to the corresponding set of plates in *Cyathocrinus.* In *Gissocrinus*, one of Angelin's Upper Silurian genera from Gotland, which is in every other respect a true *Cyathocri-*

nus, there are but three unequal plates in the proximal ring, showing here an actual metamorphosis of five plates into three.

In *Cupressocrinus*, which has a single central plate below the "subradials," pierced by the quadripartite perforation of the column, it might at first seem difficult to subdivide the proximal plate in this manner. But it will be noted that it is really radial in position, since its five external angles alternate with those of the "subradials," and furthermore, we find that nature has done it for us in a precisely similar case. *Myrtillocrinus*, whose base is perforated by a quadrangular foramen, has its proximal ring divided into five small pieces, alternating with "subradials" and hence radial in position. (15th New York Regents' Rep., p. 142.)

It is worthy of note that in the form last discussed—those with two rings below the radials—the proximal plates are almost invariably very small, and in many cases so minute as to be hidden by the column, thus in their insignificance affording an argument against comparing them with the genitals. They seem to be early developed, for they are as large in the young as in the adult, and do not show much increase in proportions in later geological epochs.

In some *Cyathocrinidæ*, the proximal ring sometimes attains considerable proportionate size, and it seems to have developed in geological time, for we find in the Lower Silurian genus *Heterocrinus* that this set of plates is represented in an extremely rudimentary stage, being only faintly visible between the sutures of the basals—"subradials"—and these plates seem to be minute in most similar Silurian genera. Yet it must not be overlooked that in many cases where the proximal plates are scarcely visible externally, they are quite prominent internally, often larger than the "subradials." This is especially the case in forms with a concave base.

In most genera with one ring of plates below the radials, the proximal plates are large and prominent, contrasting in a marked degree with the proximal plates in the two forms last considered.

There are a few genera, anomalous in structure, which cannot, with our present knowledge of them, be satisfactorily brought within the above comparison—such as *Calceocrinus*, *Catillocrinus*, *Pisocrinus*, and perhaps others.

The Blastoids, with their uniform arrangement of plates, agree well with Carpenter's interpretation, the three basals being divisible into five plates interradially arranged.

All these facts seem to indicate that the "subradials," in genera where they exist, are really the basals, and in such simple forms as *Cyathocrinus*, it seems very reasonable to consider these plates as the homologues of the genitals, and the radials as the ocular plates in the apical system of the Echini. In more complex forms, such as the *Actinocrinidæ*, *Rhodocrinidæ*, *Ichthyocrinidæ*, etc., there would seem at first to be an objection to this interpretation, arising from the fact that there are several other orders of plates, both radial and interradial, within the body walls, and that in these cases, as in *Cyathocrinidæ*, we should find the homologues of the apical plates of the Echini in the *entire calyx*, or the whole series of plates of the aboral side up to the region of the arms, and not in the two rings alone which Carpenter points out as such; in other words, that the apical plates in the Echini cannot be homologized with some few plates in the calyx of Palæocrinoidea.

In the younger stages of Paleocrinoids, the higher series of radials are unconnected by interradial or axillary plates, as may be seen most beautifully illustrated in the growth of *Strotocrinus*.[1]

It is also probable that at a still earlier period in the life of these Crinoids, the second and third primary radials constituted a free ray, as in the more simply constructed *Cyathocrinus*. In *Actinocrinus*, etc., the basals, which according to Carpenter are homologous to the "subradials" in other families, and the genitals in Echini, develop very early in the young, and attain almost their full size when even the first radials are comparatively much smaller. We have in our possession a *Cyathocrinus*, not more than half an inch in length including the arms and a portion of the column, in which, while the proximal plates are comparatively small, the so-called "subradials" are developed to an extraordinary degree, far more than the radials. The specimen in this stage looks remarkably like Billing's Lower Silurian genus *Hybocrinus*, in which the first interradial ring of plates is enormously prominent and gibbous, while the proximal ring is apparently wanting, or if it exists, is very minute.

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[1] See our paper on "Transition forms in Crinoids," Proceed. Acad. Nat. Sci. Philad., 1878, p. 233, and also pp. 229–235 for illustrations of development in the parts in question in successive epochs.

It is now a very important fact that these two rings of plates—the first radials and the interradial set of plates next below them—are the only ones which are found in *all Crinoids from the earliest geological ages to the present time.* It thus appears that the evidence derived from the embryology of the Pentacrinoid, and the observed mode and order of development in the Paleocrinoids during individual life, is fully and beautifully confirmed by the geological history of Crinoids.

All this evidence seems to us to be conclusive, and to prove satisfactorily that the two rings of plates regarded by Carpenter as genitals and oculars, are the fundamental parts in the aboral side of the calcareous skeleton, and that the subsequent orders of radials and interradials are to be considered as supplementary to them, and as the products of growth in the individual and development in geological time.

Our conclusions being thus in harmony with Prof. Carpenter's views, we think it both logical and expedient to adopt his terms, and call the first ring of plates below the radials "basals" in all cases, and the second ring below, or the proximal plates when there are two rings, "underbasals," thus discontinuing the term "subradials" altogether.

We cannot, however, agree with Carpenter in supposing, as he does, p. 374, that the underbasals have no representative in the apical system of other Crinoids or Echinoderms. We incline to the opinion of Agassiz, Lovén, and others, that they are homologous with the central disc or subanal plate of the Echini, and with the centro-dorsal plate of *Comatula.* In the paleozoic genus *Agassizocrinus*, which was evidently pedunculate in its earlier stages, but became a freefloater when mature, we find in the proximal ring in young specimens five plates with a central perforation in the disc, and a distinct articulating scar for the attachment of the column. In the free stages, however, every trace of the central foramen and of the columnar attachment has disappeared, and in most of the specimens not even a vestige of the sutures formerly existing between the plates can be detected. In some they can still be faintly observed, but only near the edges upon which the succeeding plates rest, and not in the median portion of the disc. Another example of this is seen in *Edriocrinus* (New York Geol. Rep., vol. iii. pp. 119–20) in which the bodies are when young attached to each other or to other solid bodies, and in maturity become free, and a calcareous deposit is secreted around the base, which covers and obliterates the sutures between the plates. Here again we have an actual metamorphosis—during the life of the individual—of five plates into one, and this seems to us to be strongly confirmatory of the views of Agassiz and Lovén. We are inclined to think that the plate within the ring of underbasals when it exists, as in *Marsupites*, represents the column of Crinoids generally.

Having thus discussed the relations and distinctions between some groups of the Crinoids and the differences between the *Palæocrinoidea* and the *Stomatocrinoidea*—so we should like to call all Crinoids which have an external mouth—we think it proper to indicate briefly the principles which we shall endeavor to follow in our more detailed work.

CLASSIFICATION.

In attempting to make a systematic classification of the Paleocrinoids into families and genera, we encounter the difficulties which usually confront us when we undertake to ascertain and define any divisions as they exist in nature. We can readily recognize in groups of fossils certain broad characters by which it seems natural and satisfactory to bring them together, and we generally find in the characteristic types of the respective groups an association of other characters, by which they appear sharply marked; and so long as we have to deal with typical forms in isolated specimens or groups, the work is simple enough. But when we begin to investigate large collections, and in a measure to study comparatively all the known material from specimens or descriptions, we find the subject bristling with perplexing questions. Types are found to shade into one another, characters are commingled through processes of transition, which sadly interfere with the nice definitions we think we have worked out. How to deal with such forms has always been a troublesome question with naturalists, and the diverse methods of treating it have given rise to much confusion. We have found it especially perplexing in endeavoring to define the *genera* of the Crinoids. We find for instance, two groups, each embracing a number of species, and we discover general characters which nicely separate them. Further researches presently reveal to us certain forms, including perhaps several species, which, while agreeing with one group in most of the characters, persistently differ from it in some one feature, and perhaps in this feature they agree with the other group. The question then arises, what is to be done in cases where there are aberrant forms, departing from one type in the direction of another, and blending the characters of the two? Are we to say that our groupings are worthless, and the two must be thrown into one? This produces confusion, and stands in the way of systematic study; and besides we will then probably be no nearer the truth, for we shall doubtless find a similar relation between the group thus formed and some other, which will demand a similar consolidation. On the other hand, shall we stand by the distinctions we have discovered, and range our transitional or aberrant forms into subgroups by themselves, and designate them by proper appellations? We are clearly of the opinion that the latter, judiciously pursued, is the true course, both with regard to convenience of study, and to facilitate the discovery of a natural classification. Without entering into any discussion of the value of these or any other groups as expressions of actual divisions in nature, we propose to adopt this method of treatment, and to recognize subgenera or subgroups of whatever dignity, as the facts may seem to warrant. In so doing we find it decidedly preferable to give each group a name by itself, and consider it as standing alone in its proper rank, and not to name it parenthetically as a mere adjunct to the parent group. If we err on the side of too narrow distinctions, this will only lead to renewed researches and ultimately to the truth.

By adopting this course we are also enabled to retain many generic names founded upon good characters as revealed to the authors by the material at their command, and thus give to many investigators deserved credit for work which would otherwise have to be wholly ignored.

We have in some cases found it necessary to revise and reconstruct the genus in order to bring, if possible, some order out of the confusion into which its literature had fallen. In doing this we have endeavored to give effect to the evident intention of the founder of the genus, and to improve the diagnosis by the aid of more extensive material than he had access to, as well as by the aid of the labors of other investigators.

It will be well in this connection to point out the structural distinctions which we regard as important in the separation of families and genera. On a former page we have alluded to the dome, which we believe affords excellent characters for separation into families. The general plan upon which it is constructed, whether rigid or flexible, composed of movable or immovable plates; with large oral plates, or covered with numerous small pieces; whether provided with a ventral sac; the location of the anus; all of these in our opinion form good family distinctions. Next to the vault must be considered the general construction of the calyx; the elements of which it consists; whether it has a subbasal zone; the presence or absence of interradials.as a rule; whether the animal was pedunculate or free floating; and last but not least, the structure and position of the respiratory organs.

Among the best *generic* characters in these Crinoids, we find the following: The general form of the body; the distribution and arrangement of the different plates, both in the vault and in the calyx, particularly the plates of the anal area and their proportions; the form and position of the apical dome plates, the position of the anus and whether consisting of a proboscis or simple opening; the form of the column, the shape and proportional size of its central passage; the construction of the arms and pinnulæ.

The arms and pinnulæ of the Palæocrinoidea have not received the attention which they deserve, at least not as to their generic importance. A careful study of these organs, as they occur in different genera, has convinced us, that not only the arms, but also the pinnulæ, in their variation, in their presence or absence, afford generic characters. Only of late years has attention been drawn to the ambulacral groove of the arm, when it was shown from actual observation that in some genera the furrow is covered by small plates alternately arranged. Meek and Worthen describe the arms of *Symbathocrinus* as being covered by two rows of single plates, arranged in alternation, and a similar structure has been discovered to exist in the arms of *Crotalocrinus* and *Enallocrinus*. In *Cupressocrinus*, according to Schultze, the furrow is braced over like a roof. In *Cyathocrinus Iowensis*, according to Wachsmuth, and apparently in *Gissocrinus*, Angelin, the furrow is covered by two rows of two successive plates, the plates of one row alternating with those of the other. In *Cyathocrinus longimanus*, Angl. (Iconogr. Crin. Pl. 26, Figs. 4, 5), there are in place of only two, a series of five successive plates from each side, alternately arranged. The plates of each side taper toward the end and infold over the furrow, covering it as perfectly, and in the same manner as in the two former cases. Angelin gives no description, but in his table of contents, he calls the successive plates from each side " pinnulæ."

It is easily seen that the covering to which we refer in the above-mentioned genera, is constructed upon exactly the same principle. It makes but little difference whether there are two single plates or two rows of plates alternating with each other, and it seems evident to us that if in one case they represent pinnulæ, we may well consider them to be the same in the other. It is here important to note that in those genera in which the ambulacral groove is thus covered, no regular pinnules have ever been observed, and moreover the construction is such that no additional pinnulæ could have existed; while on the other hand no covering has ever been discovered in forms with true pinnulæ. From our observation we are of opinion that the pinnulæ generally in the Palæocrinoidea served partly as a cover or protection for the furrow. In a specimen of *Graphiocrinus tortuosus*, Hall, in our collection, the pinnulæ cover the furrow so perfectly that we were for some time led to consider them as a solid integument composed of regular spiniferous plates. With a good magnifier, however, we clearly detected the joints of the pinnulæ, which are here so placed that the little spines with which their sides are provided stand up erect. In the *Actinocrinidæ* and *Platycrinidæ* the pinnulæ are long, comparatively slender, and so closely arranged side by side that it appears as if they were connected laterally, which we think is really the case in some groups. When the arms are closed, the two series of pinnulæ of one arm are laid upon each other so neatly, that the arm furrow must have been thereby perfectly shut off from the surrounding water. No additional covering has yet been observed in these genera, and it was evidently unnecessary.

All this seems to point to the conclusion that the pinnulæ had the same functions, partly at least, as the alternate plates in *Cyathocrinus*, etc., and as both have the same position, and evidently could be opened and closed by the animal, we do not hesitate to consider the latter as the homologue of the former, or in fact as rudimentary pinnulæ.

TERMINOLOGY, ETC.

There is considerable confusion in the literature of Crinoids—even among contemporaneous writers—as to the terms employed to designate the different parts of the animal. It is to be regretted that there is not some means of establishing uniformity in this respect, as this would no doubt promote better results in investigation. We believe it to be especially desirable, and for the interest of science, that there should be a better understanding on this subject between Zoologists and Paleontologists, so that the same terms may be used, so far as possible, for similar parts in both fossil and living forms. We will not assume to say how this should be brought about, but would be glad to see it undertaken by those of more experience and authority in both fields.

To avoid misunderstanding of our work we give herewith a list of the principal terms employed, with the definitions as understood and used by us. We do not seek so much to introduce new terms as to select the best—in our judgment—of those already known to our branch of science, and then to use them consistently.

Explanation of Terms.

Root = extremity of column, where attached.

Cyrrhi = radicular appendages, springing from the periphery of column joints, or in *Comatula* from the centro-dorsal plate.

Column or stem = jointed cylindrical structure below the body.

Body = the frame of the animal, excluding column and arms.

Test = the calcareous shell inclosing the internal organs.

Calyx = the dorsal cup, or the test of the *abactinal* or dorsal side up to the arms = aboral side.

Vault, dome, summit = the test above the arms; the plated covering on the ventral side = *oral side* = *actinal side.*

Ventral sac = vertical extension of the vault in its posterior area, closed at the extremity.

Anal tube or proboscis = posterior vertical elongation of the vault, with anal opening at its extremity. The term "proboscis" is so generally used that we feel compelled to retain it, although there is a serious objection to its use. The word implies that it is an oral organ used for feeding, which is, beyond the slightest doubt, directly contrary to the fact.

Posterior side = the anal side of the body.

Anterior side = the side opposite the anal area.

Right or left = viewed from the posterior side.

Rays = the whole collective succession of plates from the first radial up.

Free rays = radial extensions of the body unconnected by interradial plates.

Arms = radial extensions or branches from the body with a furrow on the ventral side.

Pinnules = small, jointed, solid appendages, alternately arranged along the arms.

Tentacles = soft prehensile organs along the ambulacral furrow of the arms and pinnules.

Ambulacral furrow = groove on the ventral side of the arms and pinnules, containing ambulacral canal and food passages.

Proximal plates = those next to the column.

Underbasals = the second ring of plates below the radials, heretofore called "basals" = pelvis of European authors.

Basals = the first ring of plates below the radials, interradially disposed, equivalent to "subradials" and "parabasals," both of which terms are discontinued by us.

Radials = all the plates of the body above the basals, radially situated.

Primary radials = those in the rays below the first bifurcation.

Secondary radials = those between the first and second bifurcation.

Tertiary radials = those between the second and third bifurcation (and so on up to the arms).

Brachials = free radial plates supporting the arms. In our former descriptions we have used the term "brachials" for that series of radial plates within the body walls which leads to an arm opening—following Hall and others. Finding, however, that this term has been previously applied to the "free radials" by Johannes Müller, and has been adopted by Roemer, Schultze, and the zoölogists generally, we propose to discontinue it as applied to the former plates, which hereafter will be designated simply as radials of their respective orders.

Interradials = plates between the rays and forming a part of the body.

Axillary plates = plates between the divisions of the rays = intersupraradials of Hall and other authors.

Interbrachials = plates between the arm openings of each ray. This term is not strictly correct, when taken in connection with our definition of "brachials," but it has been long used in this sense, and as no confusion is likely to arise, we think it best to retain it.

Anals = the series of interradial plates which support the anal opening or tube.

Apical dome plates = the system of plates in the vault which occupy a position analogous to that of the apical plates of the calyx. They consist: 1, of a central plate at the apex of the dome; 2, of five large plates (there are generally four large and two small ones, the two latter equivalent to one, being separated by the anal area), arranged around the apex, interradially disposed, and corresponding to the first radials; 3, of five radial dome plates, alternating with the last, and corresponding to the first radials. Wachsmuth, Amer. Journ. Sci., Sept. 1877, p. 187, called the first seven of these plates "apical plates." This must be changed to avoid confusion, as the genitals and oculars of Echini are designated by the same term. We now apply the term "apical dome plates" to the whole system of principal vault pieces. These plates, which have no representation in the structure of the Stomatocrinoidea nor Echini, exist in a greatly reduced form in the Blastoids, but are specially characteristic of the Actinocrinidæ, Platycrinidæ, etc. The single plate at the apex we propose to call the *central dome plates;* the first ring of interradials surrounding it, *the proximal dome plates*, and the next ring radially situated, the *radial dome plates.*

Oral plates = large interradial plates, covering in form of a pyramid the oral side of the Pentacrinoid larva (Wyville Thomson and Carpenter) = consolidating plates in *Cyathocrinus* (Wachsmuth) = deltoid pieces in Blastoidea. The term "consolidating plates" is discontinued.

Hydrospires = certain organic structures in connection with the inner walls of the test, composed of parallel tubes or folded sacs, probably in connection with the water system.

Respiratory pores or orifices = openings through the test, in connection with the hydrospires, apparently for the introduction of water for respiratory purposes.

In the discussion of the different genera we shall give with each a full list of the species which belong to it, *in our opinion*, independent of the opinion of others, and this will cause many changes in the reference of species. It cannot be expected that these lists will be free from mistakes, though we have studied each species with great care, the majority of them from the specimens, and besides our own extensive collections, one of us had occasion a few years ago to examine the original collections of De Konnick and Schultze, now in the Museum of Comparative Zoology at Cambridge. Nor can it be expected that in a general work on Crinoids like this, we shall give a full list of synonyms, and we have not attempted to do so. This can only be thoroughly done by the collector who has given his attention for years to the fossils of his own locality, and is able to identify them from the least fragment. We shall give the synonyms of the subcarboniferous Crinoids of the Mississippi Valley which we have made our special study, and we hope that investigators will do the same for other localities and formations. We shall feel under special obligations to any of our scientific friends for any information they may be able to furnish us, either in the way of specimens or observations which may contribute to a more thorough understanding and truthful presentation of the subject. We particularly desire this, as we intend to embody the results of all our investigations in this field in a future work to be issued with ample illustrations.

We take this opportunity to tender our thanks to Prof. A. Agassiz, of Cambridge; Prof. A. H. Worthen, of Illinois; Prof. S. H. Calvin, of Iowa City; Prof. A. G. Wetherby, of Cincinnati; Dr. James Knapp, of Louisville; Dr. Harrod, of Canton; Dr. K. Zittel, of Munich; Dr. F. Roemer, of Breslau; and to Prof. Trautschold, of Moscow, Russ., for valuable assistance courteously extended to us in the loan of books or specimens.

Note.—Species founded upon mere fragments of column are not recognized by us, and their names are enumerated only in the list of synonyms and doubtful species.

All species marked in front with an * are referred to said genus for the first time.

PALÆOCRINOIDEA.

A SUBORDER OF THE CRINOIDEA.

Body, as compared with recent Crinoids, larger; arms shorter; test stronger. The latter is arranged on various plans, but is always composed of solid plates of which the interradials, in contrast to the *Stomatocrinoidea*, constitute important elements. Plates of the aboral or dorsal side forming a cup, closed on the ventral or oral side by a more or less solid integument, without external food grooves or oral aperture.

The food conveyed through openings at the base of the arms into the body, and carried to the oral centre by means of internal or subtegminal passages. Anus either in form of a plated tube or a simple opening, subcentral or lateral.

The introduction of water for respiratory purposes seems to have been effected through small openings or pores which penetrate the test. These openings, which in some groups were located in the oral, in others in the aboral regions, seem to have been connected with peculiar organs within the body, closely resembling the so-called hydrospires of Cystideans and Blastoids.

The Paleocrinoids, with but few exceptions, were pedunculate, attached during lifetime. Flourishing abundantly in the Silurian seas, they reach their climax in the Subcarboniferous, as well in variety of form as in number of individuals, and they disappear almost entirely during the Carboniferous, few forms, if any, surviving as late as Mezozoic times.

FAMILY I.—ICHTHYOCRINIDÆ.

(Diagram Pl. 15, Fig. 1.)

General form of the body including arms, globose to pyriform. Column strong, perforation of medium size, generally pentangular.

Underbasals three, of unequal size; always small, often rudimentary and not visible externally, being hidden by the column. Basals five, moderately small, sometimes scarcely appearing beyond the column (in *Calpiocrinus* probably absent or imperfectly developed). Primary radials, three to five by five, almost equal in form and size. Radials of each order smaller by half than those of the preceding, and of uniform size. Arms bifurcating, short, strong, tapering upward, the tips infolding; composed of single joints. Pinnulæ unknown. In most of the genera, the arms lie side by side touching laterally, so as to form with the calyx an apparently compact wall. Radial and arm plates frequently have undulating sutures or additional patelloid plates. The radials up to the second or even the third order form a part of the body, being connected laterally either by a sort of squamous integument, composed of very minute, irregular plates, or by distinct interradial and axillary plates, the former varying in number from one to thirty or more, the anal area containing frequently a few additional plates. Anus unknown, except in *Taxocrinus* and *Onychocrinus*, which have a small lateral tube. Ventral disc rarely preserved; composed of a more or less soft or scaly integument, yielding to motion in the body and arms.

This family might very appropriately be called the Articulates of the Paleozoic Crinoids, being especially distinguished in most of its species by a peculiarity of structure which prevails throughout the rays and arms. The plates have rather shallow excavations on their outer upper margins, corresponding to projections on the lower edge of the succeeding plates, which sometimes take the form of superficial patelloid plates, independently articulated, and sometimes anchylosed with the margin of the plate above. This feature produces what seems to be an articulate structure in the whole skeleton, and indicates that the body as well as the arms was somewhat flexible. The interradial areas are sometimes found depressed and in other cases distended, showing that there had been some expansion or contraction of the body walls due to the mobility of the radial parts, and indicating likewise flexibility in the vault. This feature, which is found so far as we know, in no other family, together with the fact that in most of the genera a ventral covering has never been found preserved, leads us to infer that this portion of the body was more or less composed of rather fragile perhaps scaly material, instead of solid plates. If these Crinoids had been provided with a rigid dome, the little projections along the radial and arm plates would have interfered with the spreading of the arms, which is rather facilitated by the mobility of the dorsal side, and the pliant nature of the vault. Such motions would be likewise aided by the patelloid plates, which are generally found in large species, and in those in which the interradial spaces are comparatively rigid.

In *Onychocrinus*, the genus which evidently possessed the greatest expansive power, the radial areas being frequently found spread out horizontally, there are toward the inner or ventral side of the rays rather large plates, to which smaller ones are joined, which connect with the interradial series. They decrease in size and thickness inwardly, and connect with the dome plates. In a specimen of *Onychocrinus exsculptus*, Lyon, and another of *O. diversus*, Hall, we found the median portion of the vault preserved, the plates being irregularly arranged, rather large and thin. This important observation goes far toward proving that the *Ichthyocrinidæ* had no external oral aperture, for if any of the family were likely to have it, it would be *Onychocrinus.*

The *Ichthyocrinidæ* are nearest related to the *Cyathocrinidæ*, from which they differ in having several orders of radials included within the body; in the articulate structure of the radial portions; in the presence of interradial plates within the regions of the calyx, and in the pliant vault.

The separation of the genera in this family has always been attended with difficulty, and it cannot be denied that several of them shade into one another in a most perplexing manner. They are very closely related, and yet there is a *habitus*, peculiar to typical forms of each genus, which is not easily described, but which is readily perceived when large collections are brought together, and which Paleontologists discerned at an early day. It is the gradations—*the transition forms*—which make trouble, and have given rise to continual modifications of the generic formulæ in hope of reconciling them with new discoveries. While we cannot expect that the divisions we have made are wholly free from errors, yet we find when we arrange the different species according to the generic characters herein given, that the groupings are more nearly conformable to the recognized habitus of the fossils than any we have been able to make heretofore, and we are encouraged to hope that we may have approximated more closely to the natural divisions.

The *Ichthyocrinidæ* range from the Lower Silurian to the close of the Subcarboniferous.

We recognize the following genera:—

1. ICHTHYOCRINUS Conrad.

1836. *Euryocrinus*. Phill. Geology of Yorksh., p. 205.
1842. *Ichthyocrinus*, Conrad. Journ. Acad. Nat. Sci. Philad., vol. viii. p. 279.
1851. *Ichthyocrinus*, d'Orbigny. Cours. élem. Pal., ii. p. 144.
1851. *Ichthyocrinus*, Hall. Geol. Rep. N. York, vol. ii. p. 195.
1878. *Ichthyocrinus*, Angelin. Iconogr. Crinoid., p. 13.
1878. *Ichthyocrinus*, Wachs. & Springer. Proceed. Acad. Nat. Sci. Philad., p. 252.

A. Typical form.

General form of body, including arms, ovoid to pyriform, with almost equilateral pentamerous symmetry. Calyx bowl or cup-shaped. Underbasals three, rudimentary, of unequal size, sometimes seen only within the calyx. Basals five, very small, their upper angles acute. Radial plates of adjacent rays alternately arranged. Primary radials three to four by five, wide and short, height about equal, but increasing in width rapidly upward, the plates being wider at their upper margins than at the lower. Secondary and tertiary radials similar in form to the primaries, quadrangular in general outline, though really pentangular and hexangular, those of the same order of equal height, and half the width of those of the next order. Arms twenty to sixty or more, accumbent, infolding at the tips, and forming with the calyx an apparently solid structure. They are composed of single joints which are heavy, wider than high, quadrangular, usually with waving sutures. Arm furrows shallow, tripartite. Pinnulæ unknown. Interradial and anal plates generally absent or undeveloped at the outside, *I. nobilis*, Wachs. & Spr. alone, to our knowledge, possessing both; they are longitudinally arranged, but the anal side cannot be distinguished. Vault unknown. Column composed of very short joints near the top, increasing gradually in length downwards. Central perforation of medium size, pentagonal.

The most striking feature of this genus, by which it is easily recognized, is its symmetrical, equilateral figure, and this pervades the whole body.

Hall, in his diagram (Geol. Rep., N. York, vol. ii., pl. 45, fig. 2), figures a small intercalated plate in line with the subradials, which is evidently accidental. He does not mention it in his generic description, nor can we find it in any of our specimens. Angelin mentions a single anal plate, which is not to be found in his figure. The presence of anal, interradial, and even axillary plates in *I. nobilis* which, as far as known, is the latest representative of the genus, is very instructive, as it shows the approach to *Forbesiocrinus*. In young specimens these plates are undeveloped externally, but are plainly visible on the inner surface of the calyx.

Phillips, in 1836 (Geology of Yorksh., p. 205), described the genus *Euryocrinus*, which is possibly the same as *Ichthyocrinus*, and might be entitled to priority, but his description and figures are so unintelligible that this would be injustice to Conrad. Phillips' generic description reads as follows: "Pelvis opening pentagonal, arrangement of plates like *Encrinus*, internal cavity very large." Not much better are his figures, since they induced Bronn to consider *Euryocrinus* as a synonym of *Actinocrinus*.

Geological and Geographical distribution.—*Ichthyocrinus* is found first in the Upper Silurian, where it is represented in Europe by 3 species, in North America by 5. None have been observed in rocks of Devonian age. In the Subcarboniferous 3 species have been discovered in America, none in Europe (unless we count *Euryocrinus concavus* Phillips).

We regard the following species as belonging to this genus:—

1858. **Ichthyocrinus Burlingtonensis** Hall. Geol. Rep. Iowa, vol. i., pl. ii., p. 557. Lower Burling. limest. Burlington.

1852. **Ichthyocrinus Clintonensis** Hall. Geol. Rep. N. Y., vol. ii. p. 181, pl. 41, figs. 6 a, b, c. Niagara gr. New York State.

1865. **Ichthyocrinus Corbis** Winchell & Marcy. Memoirs Bost. Soc. Nat. Hist., vol. i., No. 1, p. 89. Niagara gr. Chicago, Ill.

Regarded by Hall as syn. of *Ichthyocr. subangularis*.

*1879. **Ichthyocrinus Gotlandicus** Wachs. & Spr. (**Ichthyocr. lævis** Angl. not Conrad.) Iconogr. Crinoid., p. 13, pl. 9, figs. 87 a–c, and pl. 22, figs. 20, 21. Upper Silur. Gotland, Swed.

The Swedish specimens, which by Angelin were identified as *I. lævis*, Conr., are very distinct from the New York species which Conrad described. The European form is pear-shaped instead of ovoid, the plates ornamented, but without any surface angularity, and with nearly straight sutures; while the New York specimens have plates with smooth but angular surface, and very distinct waving sutures. We therefore suggest their separation, and propose to call the Swedish form *I. Gotlandicus*.

1878. **Ichthyocrinus intermedius** Angelin. Iconogr. Crin., p. 13, pl. 17, fig. 7. Upper Silur. Gotland, Swed.

1842. **Ichthyocrinus lævis** Conrad (not Angl.) Type for the genus. Journ. Acad. Nat. Sci. Philad., vol. xiii. p. 279, pl. 15, fig. 16; also 1852, Hall, Pal. N. York, vol. ii. p. 195, pl. 43, fig. 2. Niagara gr. Lockport, N. Y.

1878. **Ichthyocrinus nobilis** Wach. & Spr. Proceed. Acad. Nat. Sci. Philad., p. 254. Upper Burl. and Keokuk transition bed. Burlington, Iowa.

1839. **Ichthyocrinus pyriformis** Phillips. (**Cyathocr. pyriformis.**) Sil. System, p. 672, pl. 17, fig. 6; also Iconogr. Crin., p. 13, pl. 17, fig. 6; and pl. 22, fig. 22. Upper Silur. England and Sweden.

*1852. **Ichthyocrinus simplex** Hall. (**Lecanocr. simplex.**) Geol. Rep. N. York, vol. ii. p. 202. pl. 44, figs. 2 a, b, c. Niagara gr. Lockport, N. Y.

Hall's figure evidently represents a young *Ichthyocrinus*, and not a young *Lecanocrinus* as he supposed.

1862. **Ichthyocrinus subangularis** Hall. Trans. Alban. Inst., Article xii., p. 7. Niagara gr. Waldron, Ind.

1850. **Ichthyocrinus tiaræformis** Troost. (**Cyathocr. tiaræformis.** Troost's Catal., and Geol. Rep. Iowa, vol. i., part ii., p. 558. Subcarbon. Tennessee.

B. Subgenus HOMALOCRINUS Angelin.

1878. Iconogr. Crinoid., p. 11.

We consider *Homalocrinus* not sufficiently distinct from *Ichthyo crinus* to rank it as a full genus, but propose the name for a division under *Ichthyocrinus*. The following is a translation of Angelin's generic description: "Body including arms ovoid. Basals three, small. Parabasals five, triangular, placed between the sides of the primary radials. Primary radials transverse, and in the form of a half moon. Interradials three, the lower one heptagonal and large, with two small ones above. Anals three, subequal. Rays several times dichotomizing." Angelin described *Ichthyocrinus* without interradials or anals, and it seems that upon this feature mainly he separates *Homalocrinus*. We find, however, in the only known species the anal area slightly different from the interradial, and the primary radials, instead of increasing from the base upward, as is the case in all *Ichthyocrini*, decrease in the same direction, the first radial being here the larger plate. The latter feature has induced us to retain *Homalocrinus* subgenerically and place it under *Ichthyocrinus*, with which it has the closest affinities.

1878. **Homalocrinus parabasilis** Angelin. Iconogr. Crin., p. 11, pl. 16, figs. 29, 30. Upper Silur. Gotland, Swed.

2. CLEIOCRINUS Billings.

1856. Geol. Surv. Canada, p. 276.
1859. Ib. Decade iv., p. 52.

The generic description was made from a single specimen, and this was in several respects defective. *Cleiocrinus* has, according to Billings, five basals alternating with the radials, and forming with them a belt around the column. Such a structure has never been found in any Crinoid. In the typical specimen, the comparatively large column conceals from view the lower part of the calyx, a space large enough to accommodate one or two series of plates, and analogy suggests that this may have been the case. The five plates which Billings found alternating with the primary radials, and which he called basals, are certainly interradials; and as the specimen in every visible character closely resembles *Ichthyocrinus* and allied forms, we have good reason to suppose that it, like those forms, possessed five small basals and three underbasals, both hidden by the column. The latter were probably very minute and rudimentary, since the specimen is from the Lower Silurian, where it is almost the only representative of the family. This alone induces us to try to define generic characters from a single imperfect specimen. Notwithstanding, therefore, that some of the elements are problematic, we propose until something better is found, the following:—

Revised generic description.—Calyx obconical or pyriform, with bilateral symmetry. Underbasals probably three, minute or rudimentary. Basals probably five, very small and hidden by the column. Primary radials three by five, increasing in width upwards, supporting several superior orders of radials all dichotomizing uniformly, and interlocking laterally with those of adjoining rays. Interradials, so far as known, one. Anals four to five, longitudinally arranged. *C. regius* has six orders of radials, the number of plates doubling with each bifurcation, which gives in the sixth order 64 brachials to each ray or 320 to the individual. Whether the small appendages which are seen at the top of the specimen were arms, cannot be determined from the figure.

The only known species is:

1856. **Cleiocrinus regius** Billings. Geol. Rep. Canada, p. 276; and 1859, Decade iv., p. 53, pl. 5, figs. 1 a–g. Trenton limest. Ottawa, Can.

Billings refers to this genus two other species, *C. grandis* and *C. magnificus*, which he described from mere fragments of the column, but which we cannot recognize. The fragments may belong to *C. regius*, or to almost any other genus.

3. ANISOCRINUS Angelin

1878. Iconogr. Crinoid., p. 13.

General form of body, including arms, ellipsoid. Calyx bowl-shaped; figure bilateral.

Underbasals three, hidden by the column. Basals of medium size, dissimilar in form. Primary radials three to five, the first widest, almost as large as second and third together; the second smallest of all. Secondary radials two, gradually increasing in size upward, the bifurcating plate almost as wide as the third primary radial. Arms apparently free above the secondary radials, accumbent as in *Ichthyocrinus*, and composed of transverse joints. Interradials one (sometimes with a small triangular piece above), very large, resting with the lower angle against the short upper lateral sides of the first radials, forming with them a compact wall. Anals two, very large, the upper one the largest plate in the body; the acute angle of the lower leaning against the basals, with the lower lateral sides resting against the adjoining subradials, and its upper lateral sides against the large first radials. The second anal plate rests upon the upper truncated side of the lower one, being in line with the interradial plates, and reaches like them up to the top of the secondary radials.

The arrangement and size of the interradial and anal plates are the characteristic features of this genus. Angelin's descriptions are rather indistinct on this point, and in order to have it properly understood, we give almost a specific description, which will probably have to be modified when more species are discovered.

Only two species are known.

1878. **Anisocrinus interradiatus** Angelin. Type for the genus. Iconogr. Crin., p. 13, pl. 22, figs. 18, 18 a. Upper Silur. Gotland.

*1852. **Anisocrinus Angelini** Wachs. & Spr. (Lecanocrinus macopetalus Angelin (not Hall). Iconogr. Crin., p. 12, pl. 19, figs. 3, 4; and pl. 22, fig. 24. Upper Silur. Gotland, Swed.

The Swedish form with its enormous interradial plate is not only specifically but even generically distinct from *Lecanocr. macropetalus*, Hall. Of the two specimens figured by Angelin, the one, pl. 19, fig. 3, agrees in every respect with *Anisocrinus*, while the other, fig. 4, differs from it in having a small, evidently abnormal plate, intercalated on the posterior side. We propose for this species the name of *Anisocrinus Angelini*, in honor of the late Prof. Angelin, the author of the genus.

4. CALPIOCRINUS Angelin.

1878. *Calpiocrinus* Angl. Iconogr. Crinoid., p. 12.
1878. *Clidochirus* Angl. (syn.). Iconogr. Crinoid., p. 12.

General form of body, with the arms closed, ovoid or pyriform. Calyx bowl-shaped, composed apparently of only one ring of plates below the radials; figure bilateral. This ring consists of three plates, one of them small, the two larger ones equal, forming together a pentagonal disc. Primary radials three by five, three times wider than high, differing in size and form; the first one lunate, the second quadrangular, the third and largest pentagonal. Secondary radials three to four, about equal in size, except those in the posterior rays whose lateral margins retreat to give space for the large anal plates. The upper secondary radials support the arms, some of which bifurcate, while others remain free. Arms similar to those of *Ichthyocrinus*, their sides closely abutting, forming a wall continuous with that of the calyx. Arm joints transverse, quadrangular. Interradials rarely more than one, which is small, wedged in between the second and third radials of adjacent rays. Anals three to five, longitudinally arranged, the lower and smallest which is almost triangular resting upon the basal plates, the upper one extending to the top of the secondary radials. Column slender, round, composed of very thin segments; central perforation small, stellate.

This genus, as described by Angelin, differs from all the rest of the family in having but one ring of plates below the radials, and this consists of three plates, unequal but apparently so proportioned as to be partly radial and partly interradial in position. The various figures, however, disagree in the latter respect. Such a structure would seem to warrant its separation into a distinct family, but as *Calpiocrinus* agrees in all other characters with the *Ichthyocrinidæ*, we feel satisfied that it naturally belongs here. We are inclined to think that in this genus the lower ring of plates is the analogue of the underbasals, and that the true basals, if not absent, are exceedingly rudimentary. We take the small triangular plate which has been called the first anal plate, to be the basal (subradial) on the posterior side which is larger in the whole family, and that the plates on the four other sides are very minute or only visible in the inside.

The presence of but one ring of plates visible below the radials, the bilateral symmetry of the calyx, and the longitudinal arrangement of the anal plates, are the most prominent characters of the genus.

Angelin, on the same page, describes the genus *Clidochirus* with a single species, which agrees with *Calpiocrinus* in every respect, except that it has no interradial plates, and four instead of three first radials—variations which may be expected even in the same species.

Geological and Geographical Distribution.—Found thus far only in the Upper Silurian of Gotland, where the following species have been discovered:

1878. **Calpiocrinus fimbriatus** Angelin. Iconogr. Crinoid., p. 12, pl. 29, figs. 77 a, b. Upper Silur. Gotland, Swed.
1878. **Calpiocrinus heterodactylus** Angelin. Iconogr. Crinoid., p. 12, pl. 3, fig. 10 a; and pl. 26, fig. 8. Upper Silur. Gotland, Swed.
1878. **Calpiocrinus humilis** Angelin. Iconogr. Crinoid., p. 12, pl. 23, figs. 28 a–c, and pl. 26, fig. 17. Upper Silur. Gotland, Swed.
1878. **Calpiocrinus ovatus** Angelin. Iconogr. Crinoid., p. 12; pl. 16, figs. 17–19. Upper Silur. Gotland, Swed.
*1878. **Calpiocrinus pyrum** Angelin. (**Clidochirus pyrum**). Iconogr. Crinoid , p. 12, pl. 22. fig. 23. Upper Silur. Gotland, Swed.

5 LECANOCRINUS Hall.

1852. *Lecanocrinus*, Hall. Geol. Rep., N. Y., vol. ii. p. 199.
1867. *Lecanocrinus*, Shultze. Monogr. Echinod. Eifl. Kalkes, p. 40.
1678. *Lecanocrinus*, Angelin. Iconogr. Crinoid., p. 12.

A. Typical form.

General form of body and arms subglobose to pyriform. Calyx bowl-shaped, unsymmetrical, plates heavy.

Underbasals three, unequal in size, larger than generally found in the family. Basals five, three pentagonal or hexagonal, the two others having an additional side for the lateral insertion of a small anal plate. Primary radials two or three by five, very short and wide, the first one largest. Secondary radials one to three or more, varying in number even in the individual. Arms precisely as in *Ichthyocrinus*. Interradials generally absent. Anal plates two, the lower one lying obliquely toward the right[1] side of the body between the two unequal basals, the adjoining radial, and the other anal plate. The second or upper and larger anal plate is interposed between the primary radials and the upper truncated side of the posterior basal. Column round, composed of rather large joints.

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[1] It is worthy of note that in all Paleocrinoids, so far as observed, in which the anal arrangement is unsymmetrical, the odd plates are pushed out toward the right, never to the left.

Hall, Schultze, and Angelin mention no interradials in their generic descriptions, but the latter figures a specimen from Gotland, which he refers to *L. macropetalus* Hall. It has one exceedingly large interradial to each area, which occupies a wide space between the rays, opposite all the primary radials, and as high as the top of the second or third secondary radial. No New York specimen of this species has ever been found with such a plate or even a trace of it, and as the two differ besides decidedly in the size of the basals, in the form and proportions of the body, and in other characters, we consider the Swedish form even generically distinct. (See *Anisocrinus Angelini*, W. & Spr.).

Geological and Geographical Distribution.—This genus is represented in the Upper Silurian by 5 species, 4 from America, and 1 from Europe. From the Devonian but a single species is known, and none from the Subcarboniferous.

The following are the known species:—

1878. **Lecanocrinus Billingsi** Angelin. Iconogr. Crinoid., p. 12, pl. 22, fig. 25 a. Upper Silur. Gotland, Swed.

1852 **Lecanocrinus calyculus**(?) Hall. Geol. Reps., N. Y., vol. ii. p. 203, pl. 46, figs. 3 a, b. Niagara gr. Upper Silur. Lockport, N. Y.

1858. **Lecanocrinus macropetalus** Hall (not Angelin). (**Anisocrinus Angelini**, W. & Spr.). Type of the genus. Geol. Rep., N. Y. Vol. ii. p. 199, pl. 45, figs. 1 a–h. Niagara gr. Lockport, N. Y.

1852. **Lecanocrinus ornatus** Hall. Geol. Rep., N. Y., vol. ii. p. 201, pl. 44, figs. 2 a–m. Niagara gr. Lockport, N. Y.

*1862. **Lecanocrinus pusillus** Hall. (**Cyathocr. pusillus.**) New Foss. of Niagara gr. p. 6, and 28th Rep., N. Y. State Cab. Nat. Hist., pl. 15, figs. 1–6. Niagara gr. Waldron, Ind.

Winchell and Marcy, Memoirs Bost. Soc. Nat. Hist., p. 90, described a cast from the Niagara limestone of Chicago under the species *Lecanocr. pusillus*, which is probably identical with Hall's *Cyathocrinus pusillus*. The description is not sufficient to decide it fully.

1867. **Lecanocrinus Rœmeri** Schultze. Echinod. Eifl. Kalk, p. 41, pl. 3, figs. 8 a–g. Devonian. Eifel, Germ.

B. Subgenus **PYCNOSACCUS** Angelin.

1878. Iconogr. Crinoid, p. 13.

The distinction between *Pycnosaccus* and *Lecanocrinus* seems to us scarcely sufficient to warrant a full generic separation. The two agree in all essential features, except that the former, according to description, has two primary radials instead of three, and that the plates of the calyx are ornamented by radiating ridges, such as are frequently found in *Barycrinus*. Even in that genus, the ornamentation is not constant, and at the most is a very unreliable character. In *L. Rœmeri* Schultze, which has entirely smooth plates, we find in two rays only two primary radials as in *Pycnosaccus*. It is very significant that if we consider the first and second radials of *Lecanocrinus* as one plate, we obtain exactly the proportions of the first radial in *Pycnosaccus*, which in our opinion here replaces the first and second radials, while the bifurcating second radial of *Pycnosaccus* actually represents the third radial of *Lecanocrinus*. Form of body, arrangement of the anal plates, and construction and folding of the arms precisely as in *Lecanocrinus*, only that the arm plates are slightly higher.

1878. **Pycnosaccus** (?) **costatus** Angelin. Iconogr. Crinoid, p. 14, pl. 15, fig. 13. Upper Silur. Gotland, Swed.

(This species belongs probably to the *Cyathocrinidæ* (?)).

1878. **Pycnosaccus nodulosus** Angelin. Iconogr. Crinoid., p. 14, pl. 15, figs. 12, 14, and pl. 28, fig. 29. Upper Silur. Gotland, Swed.

1840. **Pycnosaccus scrobiculatus** Hisinger. (**Cyathocrinites scrobiculatus**(?)). Leth. Suec. Supplem. ii. p. 6, pl. 39, figs. 4 a–c; also 1878, Angelin. Iconogr. Crinoid., p. 14, pl. 15, figs. 10, 11. Upper Silur. Gotland, Swed.

6. **MESPILOCRINUS** De Koninck & Lehon.

1853. *Mespilocrinus*, de Kon. & Lehon. Recher. s. les Crin. Carb. Belg., p. 111.

1836. *Young Poteriocrinus*, Phillips. Geol. Yorksh., vol. ii. p. 205.

1866. *Lecanocrinus*, Schultze. Echinod. Eifl. Kalk., p. 40.

1859. *Mespilocrinus*, Hall. Supplem. Iowa Geol. Rep., p. 69.

General form of body with arms, globular to pyriform, very small. Calyx bilateral, though apparently unsymmetrical on account of the dextrorse arrangement of the arms.

Underbasals three, unequal; one quadrangular, the other two larger and pentangular. Basals five; four of them equal, the fifth larger and hexagonal, its upper face parallel with the lower. Radials three by five, the first forming part of the basal cup. Second radials wedgeform, shorter, but as wide as the first. The third radials support two arms which bifurcate once. The arms are extremely short, composed of very few joints, tapering rapidly upward, infolding, inclined obliquely from left to right, and when closed they fit so neatly one into the other, that it appears as if they formed together with the calyx a continuous body. Arm joints single, slightly cuneate. Interradials none. Anals one, subquadrangular, resting upon the larger basal. Column round, composed of thin joints near the body, increasing in length so rapidly towards its base, that in four inches the joints attain a length of half an inch. Central perforation of medium size.

L. Schultze, in his Monograph der Echinod. Eifl. Kalk., p. 40, pronounces *Mespilocrinus* a synonym of *Lecanocrinus*. In this he is evidently mistaken. *Lecanocrinus* has arms like *Ichthyocrinus*, while those of *Mespilocrinus*, in place of being straight, are turned to the right, and the radial and arm plates are consequently wedgeform instead of rectangular. Schultze's *Lecanocrinus Rœmeri*, on which he based the above conclusion, is a most interesting species to show the relations between the two genera. It occurs in the Devonian and zoölogically occupies an intermediate position between the Silurian form *Lecanocrinus* and *Mespilocrinus* of the Subcarboniferous. *L. Rœmeri* not only has very short arms, but they fold up almost as in *Mespilocrinus*, yet they have rectangular joints and are not deflected. The species has also the unsymmetrical arrangement of the anal area, but the odd plate is here exceedingly small, and has, when combined with the large one, exactly form and proportions of the single anal plate in *Mespilocrinus*, thus approaching and foreshadowing the bilateral form which succeeded in the Subcarboniferous.

Mespilocrinus seems to be strictly a subcarboniferous genus, and only four species are known:—

1853 **Mespilocrinus Forbesianus** De Koninck and Lehon. Recherch. Crin. Belg., p. 112, pl. ii., figs. 1 a–c. Mountain limest. England and Belgium.

1853. **Mespilocrinus granifer** De Koninck and Lehon. Recherch. Crinoid, Belg., p. 114, pl. ii., figs. 6 a–c. Mountain limest. Visé, Belgium.

1859. **Mespilocrinus Konincki** Hall. Supplem. Geol. Rep. Iowa, p. 69. Burlingt. limest. Burlington, Iowa.

1861. **Mespilocrinus scitulus** Hall. Prelim. Not. New Pal. Crinoids, p. 9. Burlingt. limest. Burlington, Iowa.

7. TAXOCRINUS Phillips.

1836. *Poteriocrinus*, Phillips (in part). Geol. Yorksh., vol. i. (not Miller).
1841. *Isocrinus*, Phillips. Pal. Foss. Cornw. (not H. von Meyer 1837).
1842. *Cladocrinus*, Austin. Ann. & Mag. Nat. Hist., vol. x. (not Agassiz).
1843. *Taxocrinus*, Phillips. Morris's Cat. Brit. Foss., p. 90.
1851. *Cyathocrinus*, Roemer. Leth. Geognost. (3te Ausgabe), p. 233 (not Miller).
1853. *Forbesiocrinus*, de Kon. & Leh. (in part). Recherch. Crinoid. Belg. p. 119.
1866. *Taxocrinus*, Schultze. Echinod. Eifl. Kalkes, p. 33.
1878. *Taxocrinus*, Angelin. Iconogr. Crinoid., p. 8.
1878. *Taxocrinus.*, sub-genus of *Ichthyocrinus*, Wachsm. & Spr. Proceed. Acad. Nat. Sci. Philad. p. 252.

According to Phillips (Morris's Catal. Brit. Foss), *Taxocrinus* has "5 basals; 3 radial plates in 5 series; arms dividing upon the third radial and frequently dichotomizing above this point; arms and branches of single series of joints, interbrachial and axillary plates."

This description embraces almost every genus of the *Ichthyocrinidæ*, among them *Forbesiocrinus.*

Johannes Müller, Monatsbericht der Berliner Akademie, March, 1858, was the first who mentioned the presence in *Taxocrinus* of three small pieces within the parabasalia—basals,—similar to those found by Hall in *Ichthyocrinus*, and in species which were supposed to be *Forbesiocrinus*. Müller's discovery was evidently overlooked by Hall, who in 1858 described his *Taxocrinus interscapularis* with five basals and no subradials; and in 1861, and even later, he refers several species with three basals and five subradials to *Forbesiocrinus*, which undoubtedly belong to *Taxocrinus*. Schultze, in his description of Phillips genus (Monogr. p. 32) calls the small plates "cryptobasalia," because they are always hidden by the column, and sometimes only visible within the calyx.

The tripartite proximal ring, rudimentary in some instances, is now admitted to belong to all the genera which we include among the *Ichthyocrinidæ*, and it therefore no longer forms a generic distinction.

The separation of *Taxocrinus* and *Forbesiocrinus* has always been a stumbling block to Paleontologists. De Koninck and Lehon gave as the principal distinction, that *Taxocrinus* had no anal nor interradial plates, while *Forbesiocrinus* had both, and sometimes a large number of them.

In 1866, both Meek & Worthen and Schultze wrote on this subject, and arrived independently at the same conclusion. The former, in an elaborate article in the Illinois Geological Report, vol. ii. p. 270, show that the same species may have sometimes no interradials, and again from one to three. They refer to *Taxocrinus* Hall's *Forbesiocrinus Thiemei*, which was described as having no interradials, but which has sometimes two, and which we have even found with as many as five regular interradial plates. The one, according to De Koninck, would be *Taxocrinus*, the other *Forbesiocrinus.* To amend the generic formula so as to admit species with one or two series of interradials, did not seem to those authors expedient, since the species exhibit such a wide range of variation in this character. Nor do they consider the presence of axillary plates which occur in both groups, nor the small patelliform supplementary pieces of some well-defined species of *Forbesiocrinus* a means of distinction, inasmuch as they are not always present in otherwise typical forms of that group; while well-marked species of *Taxocrinus* are described as showing the patelloid plates between the arm joints. Meek and Worthen therefore concluded, until more distinctive characters should be discovered, to place *Forbesiocrinus*—embracing species with many interradial and anal plates—as a mere section under *Taxocrinus.*

Schultze found in his Devonian species almost every character of *Forbesiocrinus* except the small patelloid plates, but whether these were sufficient to distinguish it from *Taxocrinus*, he did not wish to decide, and so he placed the species from the Eifel, in which these plates do not occur, under *Taxocrinus.* He, however, included with this genus species which evidently belong to very distinct genera.

Angelin, in the Iconographia Crinoideorum Sueciæ, pp. 8, 9, gives generic descriptions both of *Taxocrinus* and *Forbesiocrinus*, and ranges under the two genera several new species. His descriptions only differ, so far as we understand them, in this: that in *Forbesiocrinus* the number of primary radials is left an open question, while in *Taxocrinus* the number is fixed at 3 × 5; that the former had one large hexagonal anal plate (he evidently meant, to judge from his figures, "and other smaller ones succeeding"), and a considerable number of interradials, the lower one much the largest; while *Taxocrinus* has two series of anals and several interradials. The three underbasals are comparatively large in both groups. Angelin's descriptions of both genera are short, and give us but little additional information regarding their relations; on the contrary they rather increase the difficulty, as none of his species of *Taxocrinus* or *Forbesiocrinus* are true representatives of either, thus raising the question whether the Swedish species ought not to be considered as types of new genera, or at least be separated subgenerically. We prefer the latter course, and propose *Gnorimocrinus* for the former, and *Lithocrinus* for the latter.

Phillips in proposing the genus *Taxocrinus* included in it the following species, in the order in which we give them, viz., *Poteriocrinus Egertoni* Phill. 2. *Cyathocrinus tuberculatus* Miller.[1] 3. *Cyathocrinus macrodactylus;* and 4. *Cyathocrinus nobilis* Phill. The first of these, a subcarboniferous species, with no or but few interradials, must be considered, according to the most generally accepted rules of naturalists, the type of the genus. The second and third species have but one or two interradials, *T. tuberculatus*, according to Pictet's figure, one or two anals resting on the upper truncated side of the large basal. The fourth species was Koninck & Lehon's type of their genus *Forbesiocrinus.*

Now comparing the anal arrangement of the latter—or rather of *Forbesiocrinus Agassizi* Hall, which undoubtedly belongs to the same group, and in which these parts are better known—we find the large basal not truncated, and the anal series which rests directly upon it almost identical in construction with the interradial series, except that it is slightly broader, and that it consists of a few more plates. We also find in that species a considerable number of axillary pieces, which extend up to the top of the tertiary radials where the arms become free.

Referring to *Taxocrinus*, or to species with but few interradials, we find the first anal either directly upon the truncated basal as in *Taxocrinus tuberculatus*, or sometimes, in species in which the first radials join laterally, the first anal is placed opposite the second and third or even between the third radials, as in *Taxocrinus Thiemei*, but in either case, with the exception of the Swedish specimens, the anal plate has a truncated upper side, and is succeeded by from two to six similar, narrow, quadrangular plates, longitudinally arranged. The plates diminish in size upwards, and form the dorsal side of a short and slender lateral proboscis, whose ventral parts, as well as the wall supporting them, have never been found preserved, and evidently consisted of more fragile material.

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[1] Roemer, considering Miller's genus *Cyathocrinus* not distinct from *Poteriocrinus*, proposed in 1851 (Foss. Fauna d. Devon. Gebirges a. Rhein, p. 8), and again in 1855 (Lethæa Geognostica, Ausgabe III. p. 233), that all species hitherto placed under Phillips' *Taxocrinus*, be arranged under *Cyathocrinus* with *C. tuberculatus*—Miller's second species—as type, and the generic formula amended accordingly. The genus *Cyathocrinus*, however, with Miller's first specios *C. planus* as type, has been accepted by almost every other paleontologist.

Returning to the interradial series we find specimens with apparently none to three or more interradial plates, with variation even in the individual, and some with as many as nine interradials, though in no instance extending up higher than to the top of the third primary radials, above which the rays are almost always free in the fossil. This, however, was not the case in the animal. Schultze found in his *T. juglandiformis*, within the open spaces between the rays, as well as between the first divisions of the rays, a large number of very minute, uneven and twisted pieces, which evidently took the place of the larger interradial plates in all cases where those did not exist. Similar pieces were figured by Angelin in the Swedish species, and they probably were present in all *Taxocrini.*

In some well-preserved specimens of *Taxocr.* (*Forbesiocr.*) *multibrachiatus* Lyon & Cass, from Crawfordsville, Indiana, and in a *Taxocrinus ramulosus*, Hall, from Burlington, Iowa, we have had an opportunity to examine this structure. Both species have a comparatively large number of interradials, the former from three to nine, arranged in from two to four series, the other six to seven in three series. These plates are quite prominent and differ but slightly in size. The little plates in question, or the plated integument as we should rather call it—the plates seem to be imbricated—is attached to the upper series of interradials, and fills the rather large interradial space up to the top of the secondary radials, inclosing the axillary spaces between the series of the latter up to the first arm-joints, and evidently covering the entire oral side of the body. On looking at the anterior side of these specimens, the construction seems almost identical with that of *Forbesiocrinus*, except that the upper part of the interradial area is less substantial and compact; but their posterior aspect exhibits in *Taxocrinus* a small lateral proboscis, while in *Forbesiocrinus* the space is filled with heavy plates, in the latter an almost pentamerous symmetry, in *Taxocrinus* (except in the Swedish species), a distinct bilateral one. This we consider the best distinction between the two genera. (Compare Diagram, Pl. 15, Fig. 2.)

An examination of a very large series of well-preserved specimens of the two genera has led us to this conclusion, and to a modification, to this extent, of the opinion intimated by us heretofore (Proceed. Phila. Acad. Nat. Sci., 1878, p. 254), that there is no distinction between these genera. We find that in practice we can separate them quite satisfactorily by the characters herein indicated, and, accordingly, we propose the following revised generic diagnosis:—

A. Typical form.

Body, including arms, rather short, depressed; calyx cup- or bowl-shaped, with bilateral symmetry. Underbasals three, sometimes very small, unequal in size, the two larger ones pentangular, the smaller quadrangular. Basals five, four of them equal and with acute upper angles, the fifth larger, generally with truncated upper sides. Primary radials three—rarely four—by five, of nearly equal size, wider than high, quadrangular in outline, except the upper one which is pentangular. Secondary radials varying in number from three to six—the former most prevalent—slightly smaller than the primary radials, and resembling them in general form. Tertiary radials like the preceding, only comparatively smaller and supporting the arms.

Arms dichotomizing once or twice, composed of single, short joints, more or less rounded on the back; sutures frequently sinuate, and sometimes provided with supplementary patelloid plates. Interradials none to three or more—as many as nine have been observed—extending as high as the top of the second or third primary radials, with very minute, irregular plates above, which fill the entire space to the top of the secondary radials, the axillary spaces, sometimes enclosing the first arm plates, and probably covering the entire ventral side of the body.

Some species have from one to three regular axillary plates, with occasionally a single plate in the axil between the tertiary radials. Anal plates resting upon the truncated upper side of the larger basal, or sometimes placed independently in line with second and third radials. They consist of a series of from two to five narrow quadrangular plates, longitudinally arranged, the upper ones forming the dorsal side of a small lateral proboscis. Column comparatively large, rapidly tapering, composed near the body of thin joints, which gradually increase in thickness as they diminish in diameter. Central perforation of medium size, pentangular as far as observed.

Geological and Geographical Distribution.—*Taxocrinus*, so far as known, appears first in Europe, where it is represented in the Upper Silurian by 2 species, in the Devonian by 3, and in the Subcarboniferous by 2. In the United States and Canada (if we exclude *Lecanocr.(?) elegans*, from the Trenton group), it is first found in the Devonian, from which 4 species are known, and from the Subcarboniferous 13 are described.

We include in the typical form of the genus the following species:—

1856. **Taxocrinus affinis** Müller. Neue Echinod. d. Eifel, p. 244, pl. 1, figs 1, 2; also Schultze, 1866, Echinod. Eifl. Kalk., p. 34, pl. 4, fig. 2. Devonian. Eifel, Germ.

1843. **Taxocr. brevidactylus** Aust. (**Cladocrinus brevidactylus**). Ann. and Mag. Nat. Hist., vol. ii, p. 198; also Rec. and Foss. Crin., p. 89, pl. 11, fig. 4. Subcarbon, Ireland.

*1863. **Taxocr. communis** Hall. (**Forbesiocr. communis**). 17th Regts. Report. N. Y. State Cab., p. 55; also 1877, Paleont. Rep. Ohio. Vol. ii. p. 169, pl. 12, figs. 3–5. Waverly group. Richfield, O.

1836. **Taxocr. Egertoni** Phillips. (**Poteriocr. Egertoni**). Geol. Yorksh., ii. pl. 3, fig. 39. Subcarbon. Yorkshire, Eng.

*1858. **Taxocrinus Giddingei** Hall. (**Forbesiocrinus Giddingei**). Geol. Rep. Iowa, vol. i. pt. ii. p. 633, pl. 17, figs. 2, 4. Keokuk limest. Illinois, Iowa.

1865. **Taxocr. gracilis** Meek and Worthen. Proceed. Acad. Nat. Sci. Phila., p. 142; also Geol. Rep. Illinois, vol. iii. p. 421, pl. 13, fig. 3. Hamilton gr. Jackson Co., Ill. (not **Taxocr. gracilis** Schultze = **Rhopalocrinus gracilis**, Wachsm. and Spr.

*1867. **Taxocr. incurvus** Trautschold. (**Forbesiocr. incurvus.**) Crin. des jüngeren Bergk. Moskau, p. 31; also Kalkbr. von Mjatschkowa, p. 126, pl. 14, fig. 11, and pl. 15, fig. 3. Subcarb., near Moscow, Russ.

1858. **Taxocr. interscapularis** Hall. Geol. Rep., Iowa, vol. i., pt. ii., p. 482, pl. 1, fig. 3. Hamilton gr. New Buffalo, Iowa.

1867. **Taxocrinus juglandiformis** Schultze. Echinod. Eifl. Kalkes, p. 35, pl. 4, fig. 4. Devonian. Eifel, Germ.

*1861. **Taxocr. juvenis** Hall. (**Forbesocr. juvenis**), Bost. Journ. Nat. Hist., vol. vii. No. 2, p. 319. Lower Burl. limest., Burlington.

*1863. **Taxocr. Kelloggi** Hall. (**Forbesciocr. Kelloggi**), 17th Regts. Rep. N. Y. State Cab., p. 56; also Geol. Rep., Ohio, Paleont, vol. ii. p., 171, pl. 12, fig. 1. Waverly gr., Subcarb. Richfield, Ohio.

*1862. **Taxocr. lobatus** Hall. (**Forbesiocr. lobatus**), 15th Regts. Rep. N. Y. State Cab., p. 124. Hamilton gr. Ontario Co., N. Y.

*1863. **Taxocr. lobatus** var. **tardus** Hall. (**Forbesiocr. lobatus** var. **tardus**), 17th Regt's. Rep. N. Y. State Cab., p. 56; also Geol. Rep. Ohio Paleont, vol. ii. p. 171, pl. 12, fig. 1. Waverly gr. Richfield, Ohio.

1841. **Taxocr. macrodactylus**, Phillips. (**Cyathor. macrodactylus**). Paleoz. Foss. Corniv., p. 29, pl. 15, fig. 41. Subcarbon. England.

*1858. **Taxocrinus Meeki** Hall. (**Forbesiocr. Meeki**), Geol. Rep. Iowa, vol. i., pt. ii., p. 631, pl. 17, fig. 3. Meek and Worthen, 1866, **Onychocrinus Meeki**, Geol. Rep. Illinois, vol. ii. p. 243. Keokuk limest. Keokuk, Iowa.

*1858. **Taxocr. multibrachiatus** Lyon and Cass, (**Forbesiocr. multibrachiatus**), Amer. Journ. Sci , vol. xxiii. (Labelled in most American collections **Forbesiocr. Meeki** Hall.) Keokuk limest. Crawfordsville, Ind., and in Kentucky.

*1862. **Taxocr. nuntius** Hall. (**Forbesiocr. nuntius**), 15th Regt's Rep. N. Y. State Cab., p. 124. Hamilton gr. Erie Co., N. Y.

1855. **Taxocr. Orbignii** McCoy. Synops. Foss. Brit. Pal. Rocks, p. 53, pl. 1 D., fig 1. Upper Silur. Westmoreland, Eng.

*1860. **Taxocr. ramulosus** Hall. (**Forbesiocr ramulosus**). Supplement Iowa Geol. Rep., p. 67 (not **Forbesiocr. ramulosus**, Lyon and Cass. = **Onychocrinus ramulosus**). Upper Burlington limest. Burlington. **Synon. Forbesiocr. sumbramulosus** Shumard, 1866.

1851. **Taxocr. Rhenanus** F Roemer. (**Cyathocr. Rhenanus**), Foss. Fauna d. Rhein. Gebirg., p. 7, pl. 2, figs. 2 a–d. Devonian. Germany.

1860. **Taxocr. semiovatus** Meek and Worthen. Proceed. Acad. Nat. Sci. Phila., p. 389; Geol. Rep. Illinois, vol. ii. p. 272, pl. 20, figs. 4 a–b. St. Louis limest. Hardin Co., Ill.

*1858. **Taxocr. Shumardianus** Hall. (**Forbesiocr. Shumardianus**), Geol. Rep. Iowa, vol. i., pt. ii., p. 671, pl. 17, fig. 1. St. Louis limest. St. Louis, Mo.

1861. **Taxocr. Thiemei** Hall. (**Forbesiocr. Thiomei**), Bost. Journ. Nat. Hist., vol. vii. No. 2, p. 317. Burlington limest. Burlington, Iowa.

Synom. **Forbesiocrinus spinifer** Hall, 1861. Bost. Journ. Nat. Hist., vol. vii. No. 2, p. 318

1821. **Taxocr. tuberculatus** Miller. (**Cyathocr. tuberculatus**), Nat. History of Crinoidea, p. 88; also Goldfuss, 1826, Petref. Germaniæ, pl. 63, figs. 6 A, B. **Cladocrinus tuberculatus** Austin, Journ. Zool., xi. p. 197. Upper Silur. Dudley, Eng.

*1858. **Taxocrinus Whitfieldi** Hall. (**Forbesiocr. Whitfieldi.**) Geol. Rep. Iowa, vol. i., pl. 2, p. 632. Meek & Worthen, 1866, Geol. Rep. Illinois, vol ii. p. 243. Keokuk limest. Warsaw, Ill.

B. Subgenus **GNORIMOCRINUS** Wachsm. & Spr.

(*γνωριμός*, noble ; *κρῖνον*, a lily.)

In form and general habitus closely resembling *Taxocrinus.* Arms comparatively longer, figure irregular, lacking the bilateral symmetry of that genus. The basal (subradial) on the posterior side is exceedingly large, reaching almost up to the top of the adjoining first radials. The first anal plate, instead of resting upon the truncated upper side of that basal, leans against the oblique right side and the adjoining first radial. A second series of anals, generally composed of two plates, rests above the basal and first anal plate. All succeeding pieces are small, frequently, but not always, quadrangular, and form as in *Taxocrinus* a short and narrow lateral proboscis which, however, is here pushed over toward the right side of the body, thereby destroying the symmetry which is characteristic of that genus. Arms placed apart, outer face rounded, bifurcating unequally by throwing off branches toward the inner side of the ray, the outer side forming almost a straight line. Column composed of long and short and wide and narrow joints which alternate from the top, not exclusively short joints at the top as in most *Taxocrini.*

We place here the following species:—

*1878. **Gnorimocrinus Austini** Angelin. (**Taxocr. Austini.**) Iconogr. Crin., p. 9, pl. 19, figs. 11 and 11 a. Upper Silur. Gotland, Sweden.

*1878. **Gnorimocr. distensus** Angelin.[1] (**Taxocr. distensus.**) Iconogr. Crinoid , p. 9, pl. 26, figs. 7, 7 a. Upper Silur. Gotland, Swed.

*1866. **Gnorimocr. excavatus** Shultze. (**Zeacr. excavatus.**) Echinod. d. Efl. Kalkes, p. 39, pl. 7, fig 2. Devonian. Eifel, Germ.

This species differs from the rest in having an excavated base.

*1878. **Gnorimocr. expansus** Angelin. (**Taxocr. expansus.**) Iconogr. Crinoid., p. 9, pl. 20, figs. 15, 16. Upper Silur. Gotland, Swed.

*1878. **Gnorimocr. interbrachiatus** Angel. (**Taxocrinus interbrachiatus.**) Iconog. Crinoid., p. 8, pl. 29, figs. 9, 10. Upper Silur. Gotland, Swed.

*1879. **Gnorimocr. Loveni** Wachsm. & Spr. (**Cyathocr. interbrachiatus** Angel.) Iconogr. Crinoid., p. 23, figs. 2, 2 a. Upper Silur. Gotland, Swed.

This species differs from *Cyathacrinus* both in the arrangement of the anal plates and in the presence of interradials. *Gnorimocr. interbrachiatus* being preoccupied, we have named it in honor of Prof. Lovén of Stockholm.

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[1] In this species, as also *Gnorimocr. punctatus,* the irregular arrangement of the anal area is not sufficiently shown in the figures, and both may possibly belong to *Taxocrinus.*

*1878. **Gnorimocrinus oblongatus** Angelin. (**Taxocr. oblongatus.**) Iconogr. Crinoid., p. 8, pl. 20, fig. 17. Upper Silur. Gotland, Swed.

*1878. **Gnorimocrinus ovalis** Angelin. (**Taxocr. ovalis.**) Iconog. Crinoid, p. 8, pl. 20, figs. 13, 14, Upper Silur. Gotland, Swed.

*1878. **Gnorimocr. punctatus** Angelin. (**Taxocr. punctatus.**) Icongr. Crinoid., p. 9, pl. 23, figs. 4, 5 (fig. 27(?)). Upper Silur. Gotland, Swed.

*1878. **Gnorimocr. rigens** Angelin. (**Taxocr. rigens.**) Iconogr. Crinoid., p. 9, pl. 11, figs. 7, 8. Upper Silur. Gotland, Swed.

*1878. **Gnorimocr. Salteri** Angl. (**Taxocr. Salteri.**) Iconogr. Crinoid., p. 9, pl. 23, figs 1, 1 a. Upper Silur. Gotland, Swed.

*1878. **Gnorimocr. tubuliferus** Angl. (**Taxocri. tubuliferus.**) Inconogr. Crinoid., p. 9, pl. 20, figs. 11, 12. Upper Silur. Gotland, Swed.

8. FORBESIOCRINUS De Koninck & Lehon.

(Diagr. Pl. 15, Fig. 1.)

1853. *Forbesiocr.*, De Kon. & Leh. Recherches s. l. Crin. Belg., p. 18.
1858. *Forbesiocr.*, Hall. Geol. Rep. Iowa, vol. i. pl. 2, p. 628.
1866. *Taxocrinus*, Meek & Worth. Geol. Rep. Illinois, vol. ii. p. 269.
1878. *Forbesiocrinus,* Angl. Iconogr. Crinoid., p. 9.

A. Typical form.

Comparatively larger than any other genus of the *Ichthyocrinidæ.* Body, including arms, broad, short, almost equilaterally pentamerous. Calyx very large, plates heavy and nodose, radial portions prominent. Underbasals three, small, hidden by the column, two of them of equal size, the third smaller. Basals five, four about equal, the one at the posterior side larger, rarely truncated. Primary radials three to four by five, generally four, but varying in number in the individual; large, almost equal in size and form. Secondary radials two, three, four, or more to the series, about half as large as the primary radials, and of the same general form. Tertiary radials smaller than those of the preceding order and comparatively shorter, the rays becoming free at the second, third, or fourth plate. Arms long, dichotomizing, infolding at the tips so that their full length is seldom observed. They are composed of single, short plates, slightly rounded at the back, with a deep ventral furrow. Arm joints in corresponding subdivisions of the same size, those in each succeeding order smaller by about one-half. The sutures of the radial and arm plates strongly sinuate, and partly occupied by additional patelloid plates. Interradial area extending to the top of the tertiary radials, and composed of a large number of plates, from ten to twenty or more, which decrease in size gradually upward, the lower one being about half the size of the primary radials.

Axillary plates from ten to twenty and more, with occasionally one to three within the axil of the tertiary radials. Anal area without lateral proboscis or visible aperture, slightly wider than the interradial areas and similarly arranged, with generally two plates in the first series instead of one. Dome unknown, but evidently to some extent flexile. Column large, tapering downward, with very thin joints next the body; central perforation of medium size, pentagonal.

The most important distinction between *Forbesiocrinus* and *Taxocrinus* is to be found in the construction of the anal and interradial areas. Unfortunately the type specimen of the former genus is in these particular parts very imperfect. We therefore propose, until better specimens of *Forbesiocrinus nobilis* De Kon. & Leh. are discovered, to make *Forbesiocrinus Agassizi* Hall the type of the genus. This large and beautiful species from the Burlington limestone evidently belongs to the same group, and has been found in excellent preservation.

Geographical and Geological Distribution.—Forbesiocrinus is not distinguished for a great variety of form, nor for abundance of individuals. In Europe, there has been found only one species from the Mountain limestone of England In the United States, it is represented by four species, all from the Subcarboniferous.

We recognize the following species as belonging to this genus:

1858. **Forbesiocr. Agassizi** Hall. (Proposed type). Geol. Rep. Iowa, vol. i., pt. 2, p-631; also Suppl. Iowa Geol. Rep., p. 65. Upper Burlgt. limest. Burlington, Iowa. *Synon. F. Agassizi* var. *giganteus*, Meek & Worth. Geol. Rep. Illinois, vol. iii. p. 495, pl. 18, fig. 3.

1859. **Forbesiocr. Cestriensis** Hall. Suppl. Geol. Rep. Iowa, p. 68. Chester limest. Pope Co., Ill.

1853. **Forbosiocr. nobilis** De Kon. & Leh. (original type). Recherches s. l. Crin. Belg. p. 121, pl. 2, figs. 2 a, b. *Poteriocr. nobilis* Phill. is probably a synonym. Mountain limest. Yorkshire, Engl.

1858. **Forbesiocr. Wortheni** Hall. Geol. Rep. Iowa, vol. i., pt. 2, p. 632, pl. 17, fig. 5. Keokuk limest. Keokuk, Iowa, and Crawfordsville, Ind.

B. Subgenus **LITHOCRINUS** Wachs. & Spr.

(λιϑος, a stone; κρῖνον, a lily.)

Prof. Angelin, in the Iconogr. Crinoid. Suec., p. 9, has described several Gotland species under *Forbesiocrinus*, which we propose to separate subgenerically. They differ from all subcarboniferous species of this group in having larger underbasals, fewer plates in the interradial and anal areas; in exhibiting a strong tendency to a bilateral figure instead of a pentahedral; in having comparatively much larger and higher first, and shorter second and third radials; also in the exceedingly large first interradial and first anal plate. Arms, so far as observed, free above the secondary radials, but only toward the inner side of the ray; the outer side forming almost a straight line. No pinnulæ observed. Column round, composed of alternately larger and smaller joints not tapering in diameter downward.

This division embraces the following species:—

*1878. **Lithocrinus divaricatus** Angelin. (**Forbesiocr. divaricatus**). Iconogr. Crinoid., p. 9, pl. 21, fig. 21, and pl. 28, fig. 3. Upper Silur. Gotland, Swed.

*1878. **Lithocr. Milleri** Angelin. (**Forbesiocr. Milleri.**) Iconogr. Crinoid, p. 9, pl. 21, fig. 16, and pl. 28, fig. 1. Upper Silur. Gotland, Swed.

*1878. **Lithocrinus obesus** Angelin. (**Forbesiocr. obesus.**) Iconogr. Crinoïd., p. 9, pl. 21, fig. 18, and pl. 28, fig. 2. Upper Silur. Gotland, Swed.

*1878. **Lithocr. robustus** Angelin. (**Forbesiocr. robustus.**) Iconogr. Crinoid., p. 9, pl. 21, figs. 11, 12. Upper Silur. Gotland, Swed.

9. ONYCHOCRINUS Lyon & Casseday.

1859. *Onychocrinus*, L. & C. Am. Journ. Sci., vol. xxix. p. 77.
1861. *Onychocrinus*, Meek & Worth. Geol. Rep. Illinois, vol. ii. p. 242.
1861. *Forbesiocrinus*, Hall. Bost. Journ. Nat. Hist., vol. vii. p. 321.

Body extended in five free rays, which are sometimes spread out horizontally; arms resembling the talons of a fowl. Calyx depressed saucer or low cup-shaped.

Underbasals three, of unequal size, rarely seen beyond the column. Basals five, four with obtuse angles, the fifth with a truncated or slightly excavated upper side. Radials four to five (rarely six to seven) by five; comparatively large, almost of equal size. At the third, fourth, or fifth plate, the rays become free, after which they divide once, each division giving off the true arms. Arms very short, branching once or twice, disposed in clusters at the extremities, and in some species along their sides also; composed of single joints with waving sutures and deep ventral furrow. In the anal area there is a series of from three to five very narrow, quadrangular plates, which rests upon the truncated or slightly excavated upper side of the basal, and forms a small lateral proboscis as in *Taxocrinus*. Interradials three to twenty, perhaps more in some species; the first one large, resting between the first and second radials; the succeeding ones smaller, rapidly decreasing in size and thickness upward, and having an inward curvature. They are followed by very minute, irregular polygonal plates, which form the interradial portion of the vault. The radial summit areas consist of two rows of somewhat larger plates, alternately arranged, which extend to the ventral covering of the free rays, and probably throughout their full length. In the median portion of the vault, there are six rather thin but large apical dome plates. The summit, when the rays are extended, is not higher than the top of the second radials; general surface depressed. Column heavy, composed of very thin joints, tapering rapidly downward; central perforation above medium size, pentagonal.

Onychocrinus is most nearly related to *Taxocrinus*, with which it is almost identical in the construction of the anal portions. It differs, however, materially in the free rays, the arm structure, and its greater expansive power.

Lyon and Casseday took the free rays to be arms, and the true arms to be pinnulæ. These authors did not extend the genus to forms like their *Forbesiocr. ramulosus*, which has only four radials instead of five, as stated in their generic formula, though that species has all the other characters of the genus.

Hall has never recognized *Onychocrinus* as a genus, but placed *O. asteriæformis*, a typical form, under *Forbesiocrinus*. Meek and Worthen, evidently considering the small lateral proboscis the principal distinction between *Onychocrinus* and *Forbesiocrinus*, and not knowing that all *Taxocrini* have it, placed all species of this group in which they observed this appendage under *Onychocrinus*.

Geographical and Geological Distribution.—*Onychocrinus* has been found only in the Subcarboniferous of Ireland and the United States; it embraces the following species:—

1861. **Onychocr. asteriæformis** Hall. (**Forbesiocr. asteriæformis**), Descr. New Crin. Prelim. Not., p. 9; also Bost. Journ. Nat. Hist., vol. vii No. 2, p. 320. Meek and Worth **Onychocrinus asteriæformis** Geol. Rep., Illinois, vol. ii. p. 243. Upper Burlington limest. Burlington, Iowa.

1866. **Onychocr. diversus** Meek and Worth. Proceed. Acad. Nat. Sci. Phila., p. 256; also Geol. Rep., Illinois, vol. iii. p. 492. Upper Burlington limest. Burlington, Iowa.

1859. **Onychocr. exsculptus** Lyon and Casseday (Typical species). Am. Journ. Sci., vol. 29, p. 78. Keokuk limest. Hardin Co., Ky., and Montgomery Co., Ind. *Synom.* **Onychocr. (Forbesiocr.) Norwoodi** Meek and Worth. Geol. Rep., Illinois, vol. ii. p. 245, pl. 17, fig. 3.

1875. **Onychocrinus magnus** Worthen. Geol. Rep., Illinois, vol vi. p. 520, pl. 31, fig. 5. St. Louis limest. Monroe Co., Ill.

1861. **Onychocrinus Monroensis** Meek and Worth. (**Forbesiocr. Monroensis**). Proceed. Acad. Nat. Sci Phila., p. 130. 1866, **Onychocr. Monroensis**, Ill. Geol. Rep., vol. ii. p. 244, pl. 17, fig. 7. Keokuk limest. Monroe Co., Illinois.

*1846. **Onychocr. polydactylus** McCoy. (**Taxocr. polydactylus.**) Synops. Carb., Ireland, p. 178, pl. 24, fig. 7. Subcarbon. Ireland.

*1859. **Onychocr. ramulosus** Lyon and Cass. (**Forbesiocr. ramulosus** L. and C., not Hall), Am. Journ. Sci., vol. 28, p. 235. Keokuk limest. Montgomery Co., Ind.

10. NIPTEROCRINUS Wachsmuth.

1868. Proceed. Acad. Nat. Sci. Phila., p. 341.
1873. Geol. Rep. Illinois, vol. v. p. 434.

This genus was originally referred by its author to the *Cyathocrinidæ*, with which, indeed, it agrees in some of its peculiarities, but a full understanding of the true nature of its structure shows that it must be classified with the *Ichthyocrinidæ*. The number of plates which constitute the proximal ring was not then, nor is now, ascertained with certainty, owing to the fact that they extend but slightly beyond the column, and, though we are inclined to think there are but three, we cannot as yet assert it positively. The first radials in some points resemble those of *Cyathocrinus*, being exceptionally large for the *Ichthyocrinidæ*. They have above a deep rounded sinus for the reception of the second radials, on each side of which, the upper margin of the plate is nearly straight and not incurved. The latter peculiarity, which was noticed in the original description, suggests the presence of an interradial structure, and the continuance of the body between the so-called free radials, otherwise this part would have to be more inflected for the support of the dome. That an interradial structure existed in the genus, is plainly seen in a specimen of *N. Wachsmuthi* M. and W., now before us, from which we infer that the interradials extend most probably even to the succeeding order. This structure alone would be sufficient to place *Nipterocrinus* among the *Ichthyocrinidæ*, but it has also the peculiar lunulate second radials, the waving sutures, and strongly marked sinuosities of the arm plates, and apparently no proboscis, not even a vestige of that organ having been discovered, though we had occasion to examine on this point some remarkably perfect specimens.

Revised Generic Diagnosis.—Body, with arms included, short; the five rays equilateral; arms divergent. Plates of calyx unusually thin, and, as far as the top of the first radials, forming a basin or depressed cup composed of immovable plates. Succeeding plates, though connected laterally, movable.

Underbasals small, scarcely extending beyond the column. Basals much smaller than the first radials, all pentangular and of equal size. Radials three to four by five. First radials comparatively much larger than in any other genus of this family; articulating face concave, and occupying less than one-half the width of the plate; the upper margins on both sides of the scar nearly straight, almost horizontal, scarcely inflected, and supporting the interradial portions which are rarely preserved, leaving in their place, in the fossil, a wide, open space between the rays. Second and third radials short, often three or four times wider than high, lunulate, resting in the concavity of the preceding plate; the bifurcating plate almost triangular. Succeeding order of plates constructed like those of the arm, only larger, all of them much wider than high, rounded on the back, with distinct waving sutures showing deep sinuosities when the arms are closed, and indicating a great mobility in these parts. Arms divergent, tapering gradually; pinnulæ unknown. No interradials to the top of the first radials, but the succeeding radials, and probably the first plate of the next order, connected by an interradial integument, the true nature of which has not been fully ascertained, being probably similar to that in *Taxocrinus*, but composed of larger plates. Column round, thick, composed near the calyx of narrow joints.

Only two species are known, and both are from the Burlington limestone:—

1873. **Nipterocrinus arboreus** Worthen. Geol. Rep. Illinois, vol. v. p. 436, pl. 4, fig. 8. Lower Burlington limest. Burlington, Iowa.

1868. **Nipterocrinus Wachsmuthi** Meek and Worth. (Type of the genus.) Proceed. Acad. Nat. Sci. Phila., p 341; also Geol. Rep. Illinois, vol. v. p. 435, pl. 2, fig. 4. Upper Burlington limest. Burlington, Iowa.

11. RHOPALOCRINUS nov. gen.

(ρόπαλον, a club, κρῖνον, a lily.)

Schultze, in his Monogr. d. Echinod. d. Eifl. Kalkes, p. 39, describes a form under the name of *Taxocrinus gracilis*, which is very interesting, inasmuch as it combines, to some extent, the characters of several families. There are only five arms, which remain simple throughout their entire length, forming a straight line with the radials—a peculiarity found in no other genus of the *Ichthyocrinidæ.* This attracted the attention of Schultze, who suggested either a modification of the genus *Taxocrinus*, so as to admit this species, or the recognition of a new genus. In the former proposition we cannot concur, as it seems to us we must admit such peculiarities as exist in this species to be generic distinctions, or throw all forms of the *Ichthyocrinidæ* into a single genus. As to this genus, we even entertain some doubts whether it belongs to the same family.

Our genus *Rhopalocrinus*, with *R.* (*Taxocr.*) *gracilis* Schultze, as type, agrees in general form rather with *Cupressocrinus*, *Symbathocrinus* and *Graphiocrinus*—representing as many distinct families—than with *Taxocrinus;* but it differs from all of them in having a series of small plates inclosed between the rays. These plates, which Schultze calls "interbrachials," fill up, according to his description, "the intermediate spaces to the top of the second radials," being thus included within the body. If we were sure that this was the case, we should, notwithstanding the simple arm structure, place *Rhopalocrinus*, without hesitation, under the *Ichthyocrinidæ;* but, as it is, the preservation of these parts is not so satisfactory as to exclude another interpretation. The so-called interbrachial plates are seen only in one interradial space, and, as all successive plates from the radials to the tips of the arms have the same form (with the exception of the first one, which is three to four times shorter, but otherwise similar), and an almost circular articulating surface, which has never been observed in plates forming part of the body, it seems quite possible that all branches were free, and that the small plates were deposited accidentally, being either plates of the vault, or perhaps remains of the pieces which once covered the arm furrows.[1] This of course would remove *Rhopalocrinus* from the *Ichthyocrinidæ*, and bring it in close relation with such genera as *Symbathocrinus* and *Pisocrinus*, with which it agrees in its arm structure and in the narrow proboscis, which probably extended in those genera to the extremities of the arms.

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[1] The type specimen with Dr. L. Schultze's entire collection is now in the Museum of Compar. Zoölogy at Cambridge.

We propose the following generic diagnosis: General form of body, including arms, subclavate, with bilateral symmetry; plates heavy. Underbasals three, scarcely visible beyond the column. Basals five, four of them equal, regularly pentangular, the fifth much higher, becoming narrower toward the top, truncated above for the accommodation of the proboscis. Radials placed in a direct line with the arms; one ring only constituting a part of the solid body, all succeeding ones being more or less movable. First radial large, heavy, the articulating face occupying almost the entire width of the plate, circular, facing slightly outward, and perforated with an opening which communicates with the interior body and with a passage toward the dorsal side of the arms. Second radials, or first brachial plates, wide but short, evidently movable, probably connected interradially (between the rays) by small polygonal plates. Succeeding plates all of the same width and form as those of the preceding ring; their height, however, three or four times greater. Arms five, simple throughout, and closely resembling those of *Symbathocrinus;* length unknown, of almost uniform size up to the sixth plate. Ambulacral furrow covered by two rows of plates roofed together, with the median line elevated. Anal area supporting a lateral proboscis similar to that of *Onychocrinus*, but heavier, and probably extending up to the top of the arms, as in *Symbathocrinus*. Interradial spaces apparently filled by very small, uneven polygonal plates up to the second brachial. Column large, almost cylindrical, and composed of larger and smaller joints near the body.

The only known species is—

*1866. **Rhopalocrinus gracilis** Schultze. (**Taxocr. gracilis** Schultze, not **Taxocr. gracilis** Meek and Worth.) Monogr. Echinod. Eifl. Kalkes, p. 39, pl. 4, figs. 3, 3 a. Devonian. Eifel, Germ.

FAMILY II.—CYATHOCRINIDÆ.

The Cyathocrinidæ represent not only one of the largest but also one of the earliest groups of the Palæocrinoidea, and they survived every other family of that sub-order.

J. S. Miller, the author of *Poteriocrinus* and *Cyathocrinus*, the two principal genera, placed the former among the Semiarticulata and the latter under the Inarticulata, which he understood to represent two distinct families. *Poteriocrinus*, according to his views, had the plates of the calyx articulating imperfectly with each other, while the plates of *Cyathocrinus* were closely joined by sutures lined with muscular integument. It is unnecessary to examine Miller's divisions in detail, as they are based upon theory and incorrect observation, as is further shown by the fact that under the Inarticulata he united *Cyathocrinus* with *Actinocrinus*, *Rhodocrinus* and *Platycrinus*, which are of course totally distinct.

Thom. Austin's classification (1843, Rec. and Foss. Crin.) is equally unsatisfactory. He followed Miller in separating *Cyathocrinus* and *Poteriocrinus* into two distinct families, placing the former among the Platycrinidæ, and including therein *Caryocrinus;* and *Poteriocrinus* with *Symbathocrinus* among the Poteriocrinidæ. The former group is based simply upon the presence of but few plates in the calyx. In the Poteriocrinidæ, according to Austin, "the lower series of plates surrounding the body, rest on and articulate on the superior columnar joint, which also articulates by radiating striæ to the concealed dorso-central (basal) plate." By the "concealed dorso-central plate" Austin meant a little tripartite plate, which he and Phillips supposed they had discovered in *Poteriocrinus* within the ring of the underbasals, but which has been seen by nobody else, and in fact does not exist. The radiating striæ, however, are found between the calyx and column, and all along the latter between the joints in all pedunculate Crinoids. His disposition of *Cyathocrinus* is no better, as he arranges it in the same family with *Caryocrinus*, which is a Cystidean. With our present knowledge it is evident that Austin's divisions are wholly arbitrary, and not according to nature.

The next attempt at classification was made by Prof. Roemer

(1855, Lethæa Geognostica, Ausgabe III., Period I.), who went to the opposite extreme by uniting Miller's typical species of *Cyathocrinus* with *Poteriocrinus*, and placing the latter with *Woodocrinus*, *Homocrinus*, *Dendrocrinus*, *Mespilocrinus*, and *Thysanocrinus* under the Poteriocrinidæ. It has been explained elsewhere that Roemer adopted the generic name *Cyathocrinus* with Miller's *Cyathocrinus tuberculatus* as type for another group of Crinoids, which had been previously separated by Phillips under *Taxocrinus*, and ranged these with *Ichthyocrinus* and a number of other genera under the family name " Cyathocrinidæ." It will thus be understood that Roemer's Cyathocrinidæ really represent our Ichthyocrinidæ, and his Poteriocrinidæ our Cyathocrinidæ. He united in the former an assemblage of very distinct groups, and among his Poteriocrinidæ are found *Mespilocrinus*, which, as we believe, belongs to the Ichthyocrinidæ, and *Thysanocrinus*, which is distinct from any of these families.

Angelin, in his systematic arrangement of the Gotland Crinoids (Iconogr. Crin. Suec.), very correctly places *Sicyocrinus*, *Euspirocrinus*, *Ophiocrinus*, and *Botryocrinus* among the Cyathocrinidæ; but *Gissocrinus*, which closely agrees with *Cyathocrinus*, except in having three underbasals instead of five, he classes (apparently on account of this structure alone) with the Forbesiocrinidæ. We have already, in our introductory remarks, noted the difficulty of classifying the genera according to the number of proximal plates, and in *Gissocrinus* we have a good example of this.

A close and comparative study of the genera *Cyathocrinus* and *Poteriocrinus* has convinced us that, though the two are very distinct generically, they are, as between themselves and in connection with many other genera, united by very important structural features, and by right ought to be regarded as of one family. They all agree—

1. In having large oral plates supporting the ambulacral grooves and covering the ventral disc, but leaving an opening at the oral centre, which is perfectly covered by the apical dome plates. Food grooves along the vault closed by two rows of alternating pieces.

2. In the presence of a porous ventral sac, located posteriorly, and closed at the top, in which the anal functions were subordinate to other offices, probably in connection with respiration and

perhaps reproduction. Anal opening rarely observed, evidently lateral—not posterior—and low down.

3. In having the calyx constructed of only three rings of plates alternating with each other. Proximal or underbasal plates sometimes imperfectly developed or even wanting; the plates of this order rarely anchylosed. No interradials, but anal plates generally found within the calyx.

These are the dominant characters upon which we propose to establish the Cyathocrinidæ as a family.

An attempt to subdivide this family by means of differences in the construction of the anal area and presence or absence of pinnulæ into two groups, represented by *Poteriocrinus* and *Cyathocrinus*, proved unsuccessful. It is true the two typical genera are well distinguished by these characters, and most genera from the Carboniferous might readily be separated in this way; but it would be very difficult with the Silurian genera, in which the anal area is imperfectly developed. Such a division might possibly be established if we had before us the living types instead of fossils, and it is very likely that the earlier forms, which include *Heterocrinus*, *Iocrinus*, *Dendrocrinus*, *Carabocrinus*, *Hybocrinus*, and *Anomalocrinus*, in which the proximal plates or underbasals are as yet very small and scarcely visible, might also be arranged in a division by themselves. So, too, *Woodocrinus*, *Zeacrinus*, *Hydreionocrinus*, and *Cœliocrinus* are well characterized by their enormous balloon-shaped ventral sac; and in like manner *Eupachycrinus*, *Erisocrinus*, and *Stemmatocrinus*, by the dwarfing of the same organ to its minimum size, represent a transition in the direction of the Encrinidæ. All these groups apparently have some claim to be classed independently, but in doing so we should rather increase than diminish the difficulties before us, and gain nothing in the end. The genera are so closely linked together, and shade so easily from one to another, and from one group into another, that a satisfactory separation is next to impossible. But, in order to facilitate the comparative study of the genera, we have arranged them systematically in such a manner that allied types are brought together in the order in which they pass into one another, and we are confident that this arrangement will materially assist in the recognition of the genera.

The following is the list:—

CYATHOCRINIDÆ.[1]

Earlier or embryonic types:—

1. *Heterocrinus* Hall.
2. *Iocrinus* Hall.
3. *Anomalocrinus* Meek & Worth.
4. *Hybocrinus* Billings.
   Subgenus *Homocrinus* Hall.
5. *Dendrocrinus* Hall.

Typical Cyathocrinidæ:—

6. *Cyathocrinus* Miller.
7. *Lecythocrinus* Zittel (J. Müller).
8. *Gissocrinus* Angelin.
9. *Arachnocrinus* Meek & Worth.
10. *Vasocrinus* Lyon.
11. *Ophiocrinus* Angelin.
12. *Botryocrinus* Angelin.
    Subgenus *Sicyocrinus* Angl.
13. *Barycrinus* Wachsmuth.

Poteriocrinus type:—

14. *Poteriocrinus* Miller.
    Subgenus *Scaphiocrinus* Hall (modified by W. & Spr.).
    Subgenus *Parisocrinus* W. & Spr.
    Subgenus *Pachylocrinus* W. & Spr.
    Subgenus *Scytalocrinus* W. & Spr.
    Subgenus *Decadocrinus* W. & Spr.
15. *Graphiocrinus* de Kon. & Leh.
    Subgenus *Bursacrinus* Meek & Worth.
    Subgenus (?) *Phialocrinus* Trautschold.

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[1] Since writing our classification, Prof. Zittel of Munich, with whom we have exchanged notes informs us that he has separated the genera which we have united under Cyathocrinidæ into four families. (Handbuch der Petrefactenkunde, 3te Lieferung, now in press.)

1. Hybocrinidæ 2. Cyathocrinidæ	without pinnulæ, arms covered with plates.
3. Poteriocrinidæ 4. Heterocrinidæ	with pinnulæ.

We doubt whether this division can be maintained practically. *Heterocrinus* is certainly more closely related to *Hybocrinus,* which he disposes under a separate family, than to *Graphiocrinus, Philocrinus, Erisocrinus,* and *Stemmatocrinus* with which he groups it. The variety of *Poteriocrinus,* which we have proposed to call *Scytalocrinus,* has such close affinities to *Graphiocrinus* that it might well be doubted whether it would be considered as a subgenus of *Poteriocrinus* or *Graphiocrinus.* If a division of the Cyathocrinidæ should prove desirable, it would seem to us more natural to bring together *Heterocrinus* with *Hybocrinus* and *Anomalocrinus,* and to place *Graphiocrinus* and allied genera under the Poteriocrinidæ; but this would interfere with the division according to pinnulæ. The difficulties in the way of a subdivision, which we have discussed at length in our general remarks on the family, do not seem to us to be obviated by the proposed arrangement of our distinguished colaborer.

Zeacrinus type:—

16. *Woodocrinus* de Koninck.
17. *Zeacrinus* Troost.
18. *Hydreionocrinus* de Koninck.
    Subgenus(?) *Cœliocrinus* White.

Transition forms toward *Encrinus*:—

19. *Eupachycrinus* Meek & Worth.
20. *Erisocrinus* Meek & Worth.
21. *Stemmatocrinus* Trautschold.

Genera insufficiently known:—

22. *Euspirocrinus* Angelin.
23. *Carabocrinus* Billings.
24. *Cyrtidocrinus* Angelin.
25. *Pachyocrinus* Billings.
26. *Myelodactylus* Hall.

In some species of *Heterocrinus*, one of the oldest of known genera, the underbasals or proximal plates are apparently wanting; in others they are so imperfectly developed that Meek did not think proper to recognize them by the usual term, but called them sub-basals. If it happens that these plates are absent, as seems to be sometimes the case, in species which apparently belong to the same genus, it would seem improper to separate *Heterocrinus* on that ground alone, and this consideration has induced us also to place in this family, at least for the present, the allied genera *Hybocrinus* and *Anomalocrinus*, in which as yet no trace of these plates has been discovered, but which otherwise have all the characters of the typical Cyathocrinidæ. The family relations as to these genera are not altogether clear, and it will require further study and better material before we can expect to understand them fully. For the present we will content ourselves with drawing attention to some peculiarities in the structure of these early Crinoids in hope that it may lead eventually to interesting results.

We find that in *Poteriocrinus*, *Zeacrinus*, and in fact in all typical Cyathocrinidæ in which columnar or radicular cyrrhi have been observed, these appendages are radially situated. This is best observed and traced in species with a pentagonal stem, wherein the direction can be noted even in fragmentary pieces. The cirrhi here occur always along the lateral faces, and in the last-named genera, so far as observed, they are always radial, while the acute angles which are formed into elevated ridges along the column are interradial. The very opposite is the case in *Heterocrinus* and *Iocrinus*, in which the cirrhi are interradial, and the ridges of the column radial, exactly as in *Belemnocrinus*, and apparently in the Actinocrinidæ and Platycrinidæ. This might have induced us to place *Heterocrinus* and *Iocrinus* in a separate division along with *Hybocrinus* and *Anomalocrinus*, which latter two evidently belong to the same group, if we had not discovered that the same diversity of structure apparently exists in species of another family. In all *Pentacrini*, recent or fossil, that have come under our observation, the cirrhi are radial and the ridges interradial, with the exception of *Pentacrinus Johnsoni*, in which according to Austin's figure (Rec. and Foss. Crin., Pl. 15, Fig. i.) the cirrhi are situated interradially as in *Iocrinus*. Owing to this interesting coincidence, and also to the fact that in *Dendrocrinus*, which in many respects closely resembles *Heterocrinus* and its above-named associates, this columnar structure is the same as in all typical genera, we have retained these genera for the present in this family. We also retain those genera in which the five underbasals are metamorphosed into three, as in *Gissocrinus*, contrary to Angelin and Zittel, or into a single plate, as in *Stemmatocrinus*, provided they otherwise agree with the family.

In the Cyathocrinidæ, the anal area, though constructed of comparatively few plates, affords most excellent generic distinctions in their arrangement. We note two principal forms; the one, which we may call the *Poteriocrinus* form—as it is best illustrated in that genus—is generally composed of three plates in the calyx, which are arranged unsymmetrically and always directed toward the right side of the body; the other, or *Cyathocrinus* anal arrangement, with a bilateral symmetry, consists of a single plate, which rests upon the truncate posterior basal. The former occurs in connection with regular pinnulæ along the arms; in the latter the arm furrows are covered by small alternate pieces and the pinnulæ are wanting.

There is scarcely any difficulty in referring all Cyathocrinidæ, from the Upper Silurian to the close of the Carboniferous, to one of those two groups, though the anal plates vary in form more or less in every genus. In genera from the Lower Silurian this is more difficult. Yet there appears to exist even among the latter and in connection with all others, an easy gradation which indicates that both forms had very probably the same origin, and that the later ones were gradually developed from the earlier Silurian types.

Looking first at the subgenus *Iocrinus*, one of the earliest known forms of Crinoids, we find the body up to the top of the radials perfectly equilateral, all basal and radial plates having the same form; but higher up this symmetry becomes disturbed by irregularities in the disposition of the brachial plates. There are four brachials in four of the rays, short and all quadrangular, while the right posterior radial supports a peculiar bifurcating plate of the same width as the other brachials and apparently similarly articulated. Its right sloping side supports four brachials, its left a number of large, heavy, almost quadrangular plates, longitudinally arranged, rounded on the back, which have the general appearance of arm plates, and such they have been taken to be by most authors. They are, however, plates of a rather strong ventral sac, and extend to its full length forming a highly elevated ridge (Pl. 16, Fig. 3). The plates are bordered on each side by about double their number of rather delicate pieces, altogether different and transversely arranged, which from their peculiar elongate form and relative position resemble pinnulæ belonging to an appendage that looks like an arm. Now the question arises, what shall we call the bifurcating plate which gives rise both to the right posterior ray and to the ventral tube? It was certainly a movable plate, and as we mentioned before, its mode of articulation was evidently the same as that of the brachials. Shall it likewise be called a brachial? And again, was not the ventral tube here, and in Crinoids generally, originally a modified arm? This, if true, would at once explain why the anal area leans always toward the right and never to the left side of the body. Is the plate, on the contrary, an anal plate? If so, the arms in that ray would rest upon the base of the proboscis, which is not very probable. That it is a brachial with interradial functions, is illustrated in other genera. In *Dendrocrinus*, as may be seen, Pl. 16, Fig. 5, the case is substantially the same, but in that genus a regular anal plate has already appeared within the calyx, supporting the ventral sac. Here four of the *radials* are equal instead of four brachials, and the fifth is a compound plate consisting of two successive plates of about the form of the simple ones, but slightly larger. Nobody can doubt that here both the upper and lower sections of the compound plate, which are separated by a horizontal suture, are strictly radial. Looking, however, at *Homocrinus*, Pl. 16, Fig. 6, it will be found, although it differs from *Dendrocrinus* only in having the suture between the sections of the compound plate sloping instead of horizontal, that by this in itself trifling alteration, which required no modification in the form or construction of other plates, the lower portion of the original compound radial became transformed into an anal plate. This was the first step towards a *Poterocrinus* anal arrangement, and in fact to complete it required only the interposition of a third small plate (Pl. 16, Fig. 7). In confirmation of this idea it is very significant that *Dendrocrinus* is essentially a Lower Silurian genus, that *Homocrinus* is restricted to the Niagara group, and *Poteriocrinus* is pre-eminently a subcarboniferous form.

The step from *Dendrocrinus* to *Cyathocrinus* (Pl. 16, Fig. 8) was equally simple, and required only the consolidation of the compound plate into one, the simple anal plate being already developed in the former. Sometimes, however, in genera wherein otherwise the *Cyathocrinus* anal arrangement prevails, there is found alongside of the single anal plate in some species—occasionally only in a few specimens, and in *Barycrinus* and *Botryocrinus* almost as a rule—a supplementary anal piece obliquely interposed toward the right side, standing as a witness to the common origin of this and all anal plates. That there has never been observed a single instance in which the anal area was directed toward the left—not even an abnormal case—is most significant, and is strong evidence in favor of our opinion, that the ventral sac originated in the right posterior ray. It proves also that the modifications which we have mentioned as taking place in the family in geological succession, are occasionally found within the limits of a genus.

It is to be regretted that the ventral sac, owing to its position, hidden between the arms, is so rarely observed. A better knowledge of this organ, we have no doubt, would enable us to base upon it excellent generic distinctions, and it might perhaps assist in establishing subdivisions in this family. Very little is known, for instance, of the distribution and position of the pores and fissures, of the anal opening, etc., and nothing as to its internal organization.

In the Lower Silurian the ventral sac attained large dimensions. In the age of the Niagara group, Upper Silurian, it became remarkable for its singular form, in some genera coiling upon itself, or bending in all directions. In the Devonian and earlier Subcarboniferous it attained the maximum in length, and the cylindrical form prevails, but this by degrees changed into the club-shaped form, from which in the succeeding geological epochs, toward the close of the Subcarboniferous, those monstrous balloon-shaped sacs were developed, and with these, as if a culmination had been reached, the family actually terminates. The few forms which still survive can no longer be considered as true types of the Cyathocrinidæ. They are of a type prophetic of a new family which is soon to appear, and of which *Encrinus* is the leading genus. The resemblance of *Stemmatocrinus* to *Encrinus* is indeed so strong that one may well hesitate in which of the two families—Cyathocrinidæ or Encrinidæ—it should be classed. We should probably have decided in favor of the latter, if we had seen any possibility of separating *Stemmatocrinus* from *Eupachycrinus*, and *Eupachycrinus* from *Poteriocrinus*, and so on. The only real difference which we notice between the two is that in *Encrinus* the three rings of plates which form the calyx, in the Cyathocrinidæ constitute an almost flat disc, or so shallow a cup that there would be no space for a visceral cavity if covered by solid plates, and, as no trace of a ventral covering has ever been observed, it is very probable that *Encrinus* belongs to the Stomatocrinoidea.

The free floating *Agassizocrinus* (*Astylocrinus* Roemer) is another form, in regard to which doubts might be entertained whether it ought not to be ranked with the Cyathocrinidæ. Its younger stage, wherein it was pedunculate, agrees well in general structure with *Eupachycrinus*, and is very appropriately called the Cyathocrinoid form. We think it better, however, to separate the genus by itself, as in the case of *Pentacrinus* and *Comatula*, and to place it under *Astytocrinidæ* in a distinct group.

General Family Diagnosis.—Calyx composed of only three rings of plates alternating with each other, each ring composed of five plates; all succeeding plates free. The proximal ring or underbasals not unfrequently hidden from view by the column, perhaps in some cases wanting, rarely anchylosed so as to form three plates or a single one. The plates of the second ring generally varying in form, the posterior one frequently truncate. Those of the third ring or the radials, more or less pentagonal, the right posterior one often smaller on account of interposed anal plates. The succeeding order of plates which have been generally designated as "free radials," but for which we have adopted the term "brachials," consists of one to two or more by five plates on which the arms originate.

Arms simple or branching, comparatively long; either provided with rather strong pinnulæ, alternately arranged, or, in the absence of these, the ambulacral groove is covered with two rows of alternating pieces, more or less wedge-shaped, sometimes strongly cuneiform, and interlocking.

There are from one to four anal plates within the calyx. When there is a single anal, the symmetry of the body is generally bilateral, but, in case of two or more, the form is irregular, because the plates tend obliquely toward the right side of the body. The anal plates support a ventral sac, which is cylindrical, convoluted, club- or balloon-shaped, and which occasionally attains immense proportions. The sac is bordered with rows of pores or fissures; its upper extremity closed, so far as observed; the anal opening lateral. Interradial plates proper entirely wanting.

Calyx surmounted by five large oral plates, with a central opening between them, and forming at their sutures five shallow ambulacral grooves converging toward the centre. Central opening covered by the apical dome plates, and the five grooves arched over by two rows of small immovable pieces, alternately arranged.

Column round or pentagonal.

The Cyathocrinidæ differ from the Ichthyocrinidæ in having a solid inflexible vault, built up of oral plates; in possessing but a single radial to each ray; and in the absence of interradial plates.

1. HETEROCRINUS Hall.

(Diagram Pl. 16, Fig. 2.)

1843. Hall. Geol. Rep. New York, vol. i. p. 278.
1859. Billings. Geol. Surv. Canada, Decade IV. p. 48.
1865. Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 147.
1866. Hall. 24th Rep. N. Y. State Cab. Nat. Hist., p. 210.
1873. Meek. Geol. Surv. Ohio. Palæont., vol. i. p. 2.

The genus *Heterocrinus* varies from the typical Cyathocrinidæ in several important particulars: first, in the apparent absence of underbasals in some of the species; second, in certain irregularities in the radial plates. In the former respect it agrees with *Hybocrinus* and *Anomalocrinus*, in the latter with *Dendrocrinus*.

The irregularities in the radial parts seem at first sight to be totally at variance with the elementary plan of structure in the family, as the calyx here appears to be composed of more than five radial plates, some of the rays having apparently two or even more. Looking at Diagram Pl. 16, Fig. 2, showing the arrangement of plates in *H. simplex* Hall, it will be found that in the anterior and right posterior rays, there are three plates in succession, whereas there are four in each of the other rays. But it will be also observed that the first radial plate in the former is about equal in size to the first two plates combined in the three other rays. It is, therefore, not unreasonable to suppose that the two here represent a compound plate, and are homologous with the single radial in other Cyathocrinidæ. This interpretation fully restores the family relations, the two succeeding plates being considered as true brachials. A similar construction exists in *Dendrocrinus*, but there only the left posterior radial is compound.

The absence of underbasals in some of the species is a good illustration of our view that the underbasals do not constitute principal elements in the structure of the Palæocrinoidea, but are merely the result of growth and development in geological time. Even Meek, who calls the proximal plates in all other genera of the Cyathocrinidæ basals, substitutes for those of *Heterocrinus* the name "subbasals."

Generic Diagnosis.—General form elongate and slender. Calyx small, subcylindrical, tapering but slightly from the column upward.

Underbasals minute, in some species almost undeveloped, and appearing externally as subtrigonal points at the lower ends of the sutures between the basals; in some species apparently wanting entirely. Basals five, subequal, pentangular. Radials irregular; some of the rays differing from those of other genera in having compound instead of simple plates, which are divided by horizontal sutures; upper articulating margin straight. The radials are succeeded by two to four brachials, quadrangular, the upper one a bifurcating plate and supporting the arms.

Arms comparatively long, simple or branching, composed of single joints with almost parallel suture. Pinnulæ heavy, springing alternately from every second or third arm plate.

Anals not supported by the basals, but resting upon the upper sloping margins of the adjoining radials. They consist of a single row of plates, longitudinally arranged, the outer side rounded and forming a prominent ridge, which gives the appearance of an arm.

The ventral sac in this genus is but imperfectly known, but it is apparently not so robust as in *Iocrinus*. Column more or less pentagonal.

The genus *Heterocrinus* is known exclusively from the Lower Silurian, and has been found only in America, unless *Myelodactylus* (?) *heterocrinus* Angl., from the Upper Silurian, belongs to it.

The following species have been discovered:—

1859. **Heterocrinus articulosus** Billings. Geol. Rep. Canada, Dec. iv. p. 51, pl. 4, fig. 8. Trenton limest. Ottawa, Canada.

1866. **Heterocr. constrictus** Hall. 24th Rep. N. Y. State Cab. Nat. Hist., p. 210; also Geol. Surv. Ohio, Palæont., vol. i. p. 3, pl. i. figs. 10 a, b. Hudson River Gr. Cincinnati, O.

H. constrictus (var.) **contractus** Meek, 1873. Geol. Surv. Ohio, vol. i. p. 4, pl. i. fig. 11. Ibid.

1866. **Heterocr. exilis** Hall. 24th Rep. N. Y State Cab. Nat. Hist., p. 213, pl. 5, fig. 16. Hudson River Gr. Cincinnati, O.

H. exilis (var.) **exiguus** Meek, 1873. Geol. Surv. Ohio, Pal., vol. i. p. 5, pl. 1, fig. 12. Ibid.

1843. **Heterocr. heterodactylus** Hall. (Type of the genus.) Geol. Rep. N. Y., vol. i. pl. 76, fig. 11 a–o; also Geol. Surv. Ohio, Pal., vol. i. p. 12, pl. i. figs. 1 a, b (2 a, b?). Hudson River Gr. Ohio and New York.

1859. **Heterocr. inæqualis** Billings, Geol. Rep. Canada, Dec. iv. p. 51, pl. 4, fig. 7. Trenton limest. Ottawa, Canada.

1866. **Heterocr. juvenis** Hall. 24th Rep. N. Y. State Cab. Nat. Hist., p. 212, pl. 5, figs. 9, 10; also Geol. Rep. Ohio, Pal., vol. i. pl. i. figs. 3 a–c. Hudson River Gr. Cincinnati, O.

1866. **Heterocr. laxus** Hall. 24th Rep. N. Y. State Cab. Nat. Hist., p. 211, pl 5, fig. 15; also Geol. Rep. Ohio, Pal., vol. i. p. 14, pl. i. figs. 8 a, b. Hudson River Gr. Cincinnati, O.

1843. **Heterocr. simplex** Hall. Geol. Rep. N. Y., vol i. p. 280, pl. 76, figs. 2 a–d; also Geol. Surv. Ohio, Pal., vol. i. p. 7, pl. i. figs. 4, 5 (6, 7?). Hudson River Gr. Cincinnati, O.

Syn. **Heterocr. Canadensis** Billings, 1859. Geol. Rep. Canada, Dec. iv. p. 48, pl. 4, fig. 5.

1856. **Heterocr. tenuis** Billings, Geol. Rep. Canada, p. 273; also Dec. iv. p. 50, pl. 4, figs. 6 a, b. Trenton limestone. Ottawa and Montreal, Canada.

2 IOCRINUS Hall.

(Diagram Pl. 16, Fig. 3.)

1866. Desc. New Spec. Crin. by J. Hall, p. 5; reissued in 1872 in the 24th Rep. N. Y. State Cab. Nat. Hist., p. 210.

Prof. Hall, in re-describing *Heterocrinus subcrassus* Meek & Worth. as *Heterocr.* (?) *polyxo*, made use of the name *Iocrinus* for a subgenus. It seems that he was in doubt whether *Iocrinus* should be placed with *Heterocrinus* or *Poteriocrinus*, as he supposed these two genera to be closely related. In this Hall is certainly in error, since a close comparison proves them to be very distinct. Neither can we conceive how such forms as *Iocrinus crassus* can be referred to *Heterocrinus*. The two differ essentially in the anal arrangement, and in the form and construction of the radial plates, which are perfectly symmetrical and simple in the former, but irregular and compound in the latter. Such characters have heretofore always been considered of generic importance, and we accordingly adopt Prof. Hall's name but in a full generic sense, and propose for the genus *Iocrinus* the following:—

Generic Diagnosis.—General appearance somewhat similar to *Pentacrinus;* comparatively larger than *Heterocrinus;* arms longer and more frequently bifurcating; calyx more broadly spreading, and perfectly symmetrical up to the top of the radials, giving the form of a short, inverted, pentagonal pyramid with the five sides deeply concave.

Underbasals undeveloped. Basals small, pentagonal. Radials comparatively large, strong, all pentagonal, and of the same height; their upper margins truncated for nearly their entire breadth for the junction of the succeeding pieces. Brachials three to four in each ray, the upper one axillary, and supporting the first free divisions of the arms. In the right posterior ray there is interposed between the true brachials and radial plate a pentagonal bifurcating piece, which is evidently free and movable like the brachials, and of the same width. This peculiar plate, which is truly radial, supports on its right sloping side the usual number of brachials, and on the left a row of quadrangular plates, vertically arranged, extending to the tips of the arms, and forming the posterior wall of a large ventral tube. In external appearance these plates resemble the brachials and arm plates, only they are somewhat higher and not quite as wide; they are gibbous, and form an elevated ridge, which causes this appendage to resemble an arm or a branch of the ray, and so it was considered by Hall in his description of *Heterocr. polyxo.* Both sides of the mesial ridge are indented to accommodate other plates, of which there are two to each median plate, one abutting against the middle part, and the other opposite the suture. These lateral plates are delicate, three or four times wider than high, and, like the other, longitudinally arranged. Each of them contains a rather deep furrow, which in perfect specimens is arched over by a row of wedge-shaped plates which stand out prominently and appear very much like pinnulæ.[1]

Arms bifurcating frequently, gradually tapering; arm pieces, like the free radials, all projecting at the upper edge, thereby producing a sort of imbrication. Pinnulæ unknown.

Column strong, distinctly pentagonal, the angles in line with the radial plates of the body.

Geological position.—Lower Silurian.

The following two species are the only examples of this genus:—

*1865. **Iocrinus crassus** Meek & Worthen. (**Heterocr. crassus**), Proc. Acad. Nat. Sci. Phila., p. 147; also Geol. Rep. Ill., vol. iii. p 325, pl. 4, figs. 1 a–c; also vol. vi, pl. 23, fig. 1. Hudson River Gr Oswego, Ill.

*1865. **Iocr. subcrassus** Meek & Worthen. (**Heterocr. subcrassus**), Proc. Acad. Nat. Sci. Phila., p. 148; also Geol. Rep. Ill., vol. iii. p. 325, pl. 4, figs. 5 a–d; also Meek, **Heterocr.** (**Iocrinus**) **subcrassus**, Geol. Surv. Ohio, Pal., vol. i. p. 15, pl. 1, figs. 9 a, b. Hudson River Gr. Cincinnati, Ohio.

Syn. **Heterocr.** (?) **Iocrinus polyxo** Hall, 1866. 24th Rep. N. Y. St. Cab. Nat. Hist., p. 210.

3. **ANOMALOCRINUS** Meek and Worthen.

(Diagram Pl. 16, Fig. 1.)

1865. *Heterocrinus* (?) (*Anomalocrinus*) Meek & Worth. Proc. Acad. Nat. Sci. Phila., p. 148.

1868. *Hybocrinus?* (*Anomalocrinus*) Meek & Worth. Geol. Rep. Ill., vol. iii. p. 327.

1869. *Ataxocrinus* Lyon. Am. Philos. Soc., vol. xiii. p. 464.

1873. *Anomalocrinus* Meek. Geol. Surv. Ohio, Pal., vol. i. p. 17.

Generic Diagnosis.—General form of the crinoid depressed, calyx comparatively large, depressed subglobose; its form extremely irregular, scarcely two plates being of the same shape.

Underbasals unknown, and perhaps undeveloped. Basals five, small, subequal, pentagonal, wider than high, partly hidden by the column. Radials very large, of diverse forms, simple or compound, the latter divided either horizontally or vertically. Of the com-

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[1] It was to this peculiar structure that we alluded in our remarks on this family, and the similarity in the appearance of the ventral sac and the arms and pinnulæ is indeed most striking. If there is in nature any such thing as a transmutation of one organ into another, it would seem that such was the case here, and this may lead to a better understanding of the functions of the ventral sac.

pound plates, those that are divided by horizontal sutures, occur in similar rays as in *Heterocrinus*, being always found in the right posterior and either in the left lateral, or in the anterior ray. The radials of the remaining rays are either simple or bisected vertically, the two halves taken together being similar in form to the simple plates. The lower segment of the former compound plates is subquadrangular, the upper one axillary and pentagonal, its lower edge slightly concave to fit the convexity of the abutting margin below. The rays with simple radials have generally fewer brachials than those with compound plates, and this gives to the Crinoid that abnormal, irregular appearance which is the most characteristic feature of the genus.

Arms divergent at their origin; long, slender, bifurcating irregularly several times above, the divisions being often of unequal size; rounded, and composed each of a single range of pieces. Pinnulæ strong. First anal plate resting transversely between the upper sloping sides of the posterior radials; succeeding plates smaller and longitudinally arranged.

Column stout, round, composed of very thin discs or segments, and having near the base a large pentagonal opening. The segments have the appearance of being composed of numerous little anchylosed spicula of irregular size and form (Meek).

Anomalocrinus has its closest affinities with *Heterocrinus*, to which it was referred in 1865 by Meek and Worthen as a subgenus. Not so apparent are its relations to *Hybocrinus*, with which the same authors afterwards similarly combined it. It certainly differs from them both very distinctly in the shallow and depressed form of the body, in the form and arrangement of the radial plates, and in the arms.

Geological position.—Lower Silurian, so far as known.

Two species have been described :—

1869. **Anomalocrinus caponiformis** Lyon. (**Ataxocrinus caponiformis**), Trans. Am. Philos. Soc., vol. xiii. p. 464, pl. 27, figs. 0, 01, 02, 03. Hudson River Gr. Cincinnati, Ohio, and Kentucky.

1865. **Anomalocr. incurvus** Meek & Worth. (**Heterocrinus ? (Anomalocr.) incurvus**), Proc. Acad. Nat. Sci. Phil., p. 148, 1868, Meek & Worth. **Hybocrinus ? (Anomalocr.) incurvus**, Geol. Rep. Ill., vol. iii. p. 327, pl 4, fig. 3 a, b. Hudson River Gr. Cincinnati, O. The latter is probably a new species.

4. **HYBOCRINUS** Billings.

(Diagram Pl. 16, Fig. 4.)

1856. Geol. Surv. Canada, p. 274, and Dec. IV. p. 23.

(*Apiocrinites* Leuchtenberg, *Haplocrinus* Grewingh, *Homocrinus*, p. p. Eichw., *Bærocrinus* Volborth, are synonymous. See Zittel's Handb. d. Petrefactenkunde, p. 350.)

Calyx globular or pyriform, one side protuberant; composed of 5 basals, 5 radials, and 2 anal plates.

Underbasals not observed, and probably rudimentary. Basals of equal size, pentagonal. The next ring of plates consists of a large anal and four of the radials, all nearly equal in size, and alternating regularly with the basals. The anal plate is hexagonal, its two upper sides equal, the sloping right side supporting a small radial, the left a second anal plate. Both of these plates are wider than high, of about the same size, which is about one-third that of the plates below. They are separated by a vertical suture, and rest by their outer edges against the upper portion of the adjoining radials which are octagonal, while the other two are heptagonal.

Arms five, simple throughout, composed of rather heavy quadrangular joints, about as wide as high, decreasing in size slightly upward. Pinnulæ wanting. The ambulacral furrow is covered by small alternating pieces, about five to each arm-joint.

Column round, small.

The unsymmetrical form of the calyx, produced by the protuberance of the posterior side; the peculiar position and small size of the right posterior radial, and the large anal plate in line with the four larger radials, are the most remarkable features of this genus, and those by which it is easily recognized. The small radial evidently corresponds to the upper half of the compound plate in *Dendrocrinus*, while the lower half, which is here apparently absent, is perhaps represented in a portion of the large undivided anal plate.

Geological position.—Lower Silurian, and so far found only in America.

The following species have been discovered:—

1856. **Hybocrinus conicus** Billings (type of the genus), Geol. Surv. Canada, p. 274; also Decade IV. p. 29, pl. 2, fig. 2 a, b. Trenton limestone. Ottawa, Canada.

1856. **Hybocr. tumidus** Billings. Geol. Surv. Canada, p. 275; also Decade IV. p. 28, pl. 2, figs. 1 a-e. Trenton limestone. Ottawa, Canada.

1859. **Hybocr. pristinus** Billings. Geol. Surv. Canada, Decade IV. p. 23, pl. 1, fig. 2 a. Chazy limestone. Montreal, Canada.

5. DENDROCRINUS Hall.

(Diagram Pl. 16, Fig. 5.)

1852. *Dendrocrinus* Hall. Geol. Rep. N. Y., vol. ii. p. 193.

1859. *Dendrocrinus* Billings. Geol. Surv. Canada. Decade IV. p. 35.

1873. *Dendrocrinus* (subgenus of *Poteriocrinus*) Meek. Geol. Surv. Ohio, Pal., vol. i. p. 20.

A. Typical form.

General form of the crinoid elongate and slender. Calyx obconical, higher than wide, unsymmetrical.

Underbasals five, similar in form, scarcely of medium size, but extending beyond the column. Basals five, the largest plates in the calyx; four of them equal, hexagonal, the fifth or posterior one heptagonal, truncate above for the support of a large anal plate. Radials alternating with the basals all around, simple in four of the rays, pentagonal and of about equal size. The right posterior radial is compound, divided by a horizontal suture into two halves, which, taken together, have about the form of the simple plates, only slightly longer. Brachials two to five, some long and narrow, and others short and wide. Anals one, subquadrangular.

Arms long, branching; ambulacral furrow deep. Pinnulæ wanting.

Dome unknown. Ventral sac strongly developed, composed of numerous small, hexagonal, alternately interlocking plates of equal size, strengthened by little transverse or slightly oblique costæ, and so arranged as to present an ascending zigzag appearance.

Column pentagonal, or exceptionally round.

The compound plate in the right posterior ray is one of the best characters of *Dendrocrinus*, and distinguishes it readily from *Cyathocrinus* with which it is most likely to be confounded. The lower half of the radial has nearly the same position and form as the first oblique anal plate in *Poteriocrinus*, and both these plates rest against the sloping side of the posterior basal, with an anal plate on the left; but while this plate in *Dendrocrinus* is succeeded by the upper segment—a radial plate—separated by a horizontal suture (which becomes oblique in *Homocrinus*), in *Poteriocrinus* it supports a third anal plate, and by pushing the right radial to one side assumes its oblique position which it maintains throughout all genera of the *Poteriocrinus* group; while in the *Cyathocrinus* group the compound radial becomes modified into a single plate.

Geological position.—Lower Silurian with the exception of a single species from the Niagara group.

The following species are known :—

1856. **Dendrocrinus acutidactylus** Billings. Geol. Surv. Can., p. 266; also Dec. iv. p. 37, pl. 3, fig. 2 a, b. Trenton limest. Montreal, Canada.

*1843. **Dendrocr. alternatus** Hall. (**Poteriocr. alternatus**.) Geol. Rep. N. Y., vol. i. p. 83, pl. 28, figs. 1 a–f. Trenton limest. Middleville, New York.

*1870. **Dendrocr. angustatus** Meek & Worth. (**Homocr. angustatus**.) Proc. Acad. Nat. Sci. Phil., p. 30; also Geol. Rep. Ill., vol. vi. p. 492, pl. 23, fig. 8. Hudson River Gr. Illinois.

1866. **Dendrocr. caduceus** Hall. (**Poteriocr. (Dendrocr.) caduceus.**) Descr. New sp. Crin. etc., p. 3; also 24th Rep. N. Y. St. Cab. Nat. Hist. 1872, p. 208, pl. 5, figs. 7, 8; also Geol. Surv. Ohio, Pal., vol. i. p. 26, pl. 3, figs. 1 a, b, c. Hudson River Gr. Lebanon, Ohio.

1871. **Dendrocr. Casei** Meek. (**Poteriocr. (Dendrocr.) Casei.**) Am. Jour. Sci., vol. ii. (3d ser.) p. 295; also Geol. Rep. Ohio, Pal., vol. i. p. 28, pl. 3, figs. 2 a, b. c. Hudson River Gr. Richmond, Ind.

1872. **Dendrocr. Cincinnatiensis** Meek. (**Poteriocr. (Dendrocr.) Cincinnatiensis.**) Proc. Acad. Nat. Sci. Phil., p. 312; also Geol. Surv. Ohio, Pal., vol. i. p. 20, pl. 3, figs. 5 a, b. Hudson River Gr. Cincinnati, O.

1856. **Dendrocr. conjugans** Billings. Geol. Surv. Can., p. 268; also Decade iv. p. 41, pl. 4, figs. 1 a, b, and 2 a, b. Trenton limest. Ottawa, Canada.

1859. **Dendrocr. cylindricus** Billings. Geol. Surv. Can., Dec. iv. p. 44, pl. 3, figs. 8 a, b. Trenton limest. Montreal, Canada.

1872. **Dendrocr. Dyeri** Meek. (**Poteriocr. (Dendrocr.) Dyeri.**) Proc. Acad. Nat. Sci. Phil., p. 314; Geol. Surv. Ohio, Pal., vol. i. p. 24, pl. 3, figs. 3 a, b. Hudson Riv. Gr. Cincinnati, O.

1843. **Dendrocr. gracilis** Hall. (**Poteriocr. gracilis** Hall, not McCoy.) Geol. Rep. N. Y., vol. i. p. 84, pl. 28, figs. 2 a–d. Trenton limest. Middleville, N. Y. Syn. **Poteriocr. subgracilis** d'Orbigny.

1856. **Dendrocr. gregarius** Billings. Geol. Surv. Can., p. 265; also Dec. iv. p. 36, pl. 3, figs. 1 a, b, c. Trenton limest. Ottawa, Canada.

1856. **Dendrocr. Jewetti** Billings. Geol. Surv. Can., Dec. iv. p. 43. Trenton limest. Bay of Quinte, Canada.

1856. **Dendrocr. humilis** Billings. Geol. Surv. Can., p. 270; Dec. iv. p. 39, pl. 3, fig. 4. Trenton limest. Ottawa, Can.

1856. **Dendrocr. latibrachiatus** Billings. Geol. Surv. Can., p. 270; also Dec. iv. p. 39, pl. 3, figs. 5 a, b, c. Hudson River Gr. Charleston Point, Anticosti.

1852. **Dendrocr. longidactylus** Hall (Type of the genus). Geol. Rep. N. Y., vol. ii. p. 193, pl. 43, figs. 1 a–k; also pl. 42, figs. 7, a, b. Niagara Gr. Lockport, N. Y.

1868. (?) **Dendrocr. Oswegoensis** Meek & Worth. Geol. Rep. Ill., vol. iii. pl. 4, fig. 4. (The specimen is too imperfect for identification.) Hudson River Gr. Oswego, Ill.

*1867. **Dendrocr. polydactylus** Shumand. (**Homocrinus polydactylus**) Trans. Acad. Sci. St. Louis, vol. i. p. 78, pl. 1, fig. 6; also Geol Surv. Ohio Pal., vol. i. p. 22, pl. 3, fig. 9. Hudson River Gr. Richmond, Ind.

*1872. **Dendrocr. posticus** Hall (**Poteriocr. posticus.**) 24th Rep. N. Y. St. Cab. Nat. Hist., p. 209, pl. 5, figs. 5 and 6. *Poteriocr.* (*Dendrocr.*) *posticus*, Meek. Geol. Surv. Ohio, Pal., vol. i. p. 22, pl. 3, figs. 4 a, b, c. Hudson Riv. Gr. Cincinnati, O.

1856. **Dendrocr. proboscidiatus** Billings Geol. Surv. Can., p 267; also Dec. iv. p. 38, pl. 3, figs. 3 a–c. Trenton limest. Montreal, Can.

1856. **Dendrocr. rusticus** Billings. Geol. Surv. Can., p. 270; also Dec. iv. p. 41, pl. 3, figs. 7 a, b. Trenton limest. Ottawa, Can.

1856. **Dendrocr. similis** Billings. Geol. Surv. Can., p. 267; also Dec. iv. p. 40. Trenton limest. Ottawa, Canada.

1866. **Dendrocr. tener** Billings. Catalogue Foss. of Anticosti Hudson Riv. Gr. Anticosti. Miller's Cat. (We have no means of comparison.)

B. Subgenus **HOMOCRINUS** Hall.

(Diagram Pl. 15, Fig. 6.)

1852. Geol. Rep. N. Y., vol. ii. p. 185.

The following is Hall's generic description of *Homocrinus*: "Crinoidea having the calyces composed of three series of simple plates, each series consisting of five plates, sometimes one or more irregular plates intercalated between the scapular or third series of plates on one side; arms proceeding from the summit of the third series of plates, without tentacles." And he says further: "The Crinoids constituting this genus have been referred to *Poteriocrinus* and *Cyathocrinus*, the structure of which genera are somewhat different. The two species given as *Poteriocrinus* in vol. i., Palæontology of New York, should be placed under this genus, having the same simple structure and arrangement of plates, arms, etc."

The above description is so indefinite, that it includes almost every genus of the Cyathocrinidæ; the only character mentioned of generic value is the absence of pinnulæ, in which it agrees, however, with *Cyathocrinus* and *Dendrocrinus.* The typical specimens which Hall used for description were most unsatisfactory, that of *H. parvus* being evidently a very young individual, while those of *H. cylindricus* are very imperfectly preserved. In Hall's corrected list of the New York fossils he seems to have given up both *Dendrocrinus* and *Homocrinus*, as he groups the species of both under *Poteriocrinus*. In 1861, however, he described two new species under *Homocrinus*, from good specimens. They are not *Poteriocrinus*, for they have no pinnulæ, nor *Cyathocrinus*, for they have an extra intercalated plate above the basals; nor *Dendrocrinus* for that plate is not radial; but their affinities are the closest with the latter, with which they agree in all principal characters. We therefore regard *Homocrinus* as a subgenus under *Dendrocrinus*, and propose the following description, with *Homocrinus scoparius* Hall as type:—

General form and arrangement of plates like in the typical *Dendrocrinus*, except at the posterior side where the lower portion of the compound plate is pushed slightly to the rear, thereby becoming a regular anal plate or support for the ventral sac. Hence in *Homocrinus* only the upper portion of the compound plate is a radial, and there are two anal plates, one subquadrangular, between the posterior radials, and supported on the truncated basal; and a smaller one resting obliquely between two basals, the right radial and the other anal plate.

The underbasals are perhaps proportionally larger than in *Dendrocrinus*. The arms have no pinnulæ, and this, together with the different arrangement of the anal plates forms the best distinction from *Poteriocrinus*. The ventral sac is without mesial ridge or lateral costæ. Column, so far as observed, round.

Geological position, *etc.*—Upper Silurian in America. In Europe it has been found in the Devonian.

Six species are known:—

1852. ?**Homocrinus cylindricus** Hall. Geol. Rep. N. Y., vol. ii. p. 186, pl. 41, figs. 2 a, b; Hall, 1859, **Poteriocr. cylindricus.** Correct. List of N. Y. Foss. Niagara Gr. Lockport, N. Y.

(The specimens are too imperfect for identification.)

*1844. **Homocr. fusiformis** Roemer. Rhein. Ueberganzsgeb., p. 61, pl. 3, fig. 2. Schnur, **Bactocrinitis fusiformis,** Steininger's Geogr. Beschr. der Eifel, p. 38. Müller, **Poteriocrinus fusiformis,** Neue Echin. d. Eifl. Kalk., p. 260, pl. 2, fig. 2; also Schultze, Echinod. Eifl. Kalk., p. 45, pl. 5, fig. 1 a–g; Devonian. Eifel, Germany.

*1868. **Homocr. nanus** Roemer. (**Poteriocrinus nanus.**) Palæontographia, by Wm. Dunker, p. 151, pl. 29, figs. 2, 3. Devonian. Bundenbach, Germany.

1852. **Homocr. parvus** Hall. Geol. Rep. N. Y., vol. ii. p. 185, pl. 41, figs. 1 a, b, c. **Poteriocrinus parvus** Hall, 1859. Corr. List N. Y. Foss. Niagara limest. Lockport, N. Y.

(Probably a very young individual of some other species.)

1861 **Homocr. proboscidialis** Hall. Geol. Rep. N. Y., vol. iii. p. 38, pl. 82, figs. 24, 25. Oriskany sandstone. Cumberland, Md.

1861. **Homocr. scoparius** Hall. (Type of the genus) Geol. Rep. N. Y., vol. iii. p. 102. pl. i. figs. 1–9. Lower Helderberg. Litchfield, N. Y.

6. CYATHOCRINUS Miller.

(Diagram Pl. 16, Fig. 8.)

1821. Miller. A History of the Crinoidea, p. 85.
1834. Agassiz. Mém. de la Soc. de Neuch., vol. i.
1843. Austin. Monogr. Rec. and Foss. Crin., p. 59.
1853. De Koninck and Lehon. Rech. s. les Crin. Carb. Belgique, p. 81.
1858. Hall. Geol. Surv. Iowa, vol. i. pt. ii. p. 622.
1866. Meek and Worthen. Geol. Rep. Ill., vol. ii. p. 175.
1873. Meek and Worthen. Geol. Rep. Ill., vol. v. p. 400.
1877. Wachsmuth. Am. Journ. Sci. (August No.), p. 120.
1878. Wachsm. and Springer. Proc. Acad. Nat. Sci. Phila., p. 256.
Syn. 1859. *Palæocrinus* Billings. Geol. Rep. Can., Decade IV. p. 24.
Syn. *Sphærocrinus* Roemer. 1851. Beiträge, z. foss. fauna a. Rhein, p. 13.

In the Thesaurus Devonico-Carboniferus, Dr. Bigsby calls *Cyathocrinus* very appropriately "a genus full of errors." This unfortunate condition is largely due to the confusion existing among Miller's typical species, which embrace an assemblage of very distinct types. It seems even doubtful whether any of his species can be properly ranked within the genus, and this would naturally suggest the question whether *Cyathocrinus*, as Roemer has suggested, ought not to be given up altogether. We are of opinion, however, that the genus ought to stand, and that it can be so amended as to include certain forms of Crinoids which have been referred to it by later palæontologists, and which cannot be included in any other established genus.

Miller describes the genus substantially as follows: "Column round or pentangular; calyx composed of a saucer-shaped pelvis consisting of five plates, on which are in successive series five costal plates, five scapulæ, and one intervening plate, with an arm proceeding from each scapula having two hands and several fingers." A comparison will show that this description differs from *Poteriocrinus* in but a single point, viz., *Cyathocrinus* has but one intervening or anal plate, *Poteriocrinus* two or more.

Miller refers to *Cyathocrinus* the following four species: 1. *C. planus*, which ought to be the type of the genus. 2. *C. tuberculatus*, which has since been referred to *Taxocrinus*. 3. *C. rugosus* which Goldfuss made the type of *Crotalocrinus*. 4. *C. quinquangularis*, which has been conceded to be a *Poteriocrinus*. As a proof how indefinite was Miller's conception of the genus, it may be noted that three of the four species are of distinct families, while he himself places *Poteriocrinus* among the Semiarticulata, and *Cyathocrinus* among the Inarticulata.

C. planus is, therefore, the only species that need be considered with reference to *Cyathocrinus*. The "pelvis" has the typical saucer shape, with a subpentangular perforation. There are five "costals," four of them hexagonal, the fifth with a truncated superior margin; "scapulæ" of similar form to those in *Poteriocrinus*, having also a horseshoe-like impression, with a transverse perforated ridge for the reception of the first arm joint (brachial), and which is succeeded by a cuneiform bifurcating plate. The arms (or hands of Miller) bifurcate several times, and there are six fingers to each division of the ray, which *are all tentaculated on alternate sides*. Here again is mentioned a single (anal) plate interposed between the radials or "scapulæ," and this plate is placed upon the truncate costal (basal). The description applies well generically to a large number of species which have been referred to *Cyathocrinus*, differing, however, in the pinnulate (tentaculated) arms. *Not one* of those species has ever been found with pinnulæ, though we have examined with reference to this point a large number of species, and some most perfect specimens, in which the covering of the ambulacral furrow is beautifully exposed all along the arm, and in which it seems certain that if they had been provided with pinnulæ, these organs would have been preserved. A similar covering has been found, with slight modification, in three or four other genera of the Cyathocrinidæ, but never in species with pinnulæ, and this suggests the idea that they may not exist in those genera. We therefore consider the presence or absence of pinnulæ of generic importance, and do not hesitate to say that if Miller's *Cyathocrinus planus* had pinnulæ, it cannot be classified with species in which these organs are wanting; and we also feel assured, from analogy, that if this was the case in *C. planus*, it will be found to possess more than one anal plate in the calyx, and prove to be a true *Poteriocrinus*.

Miller figures three specimens of this species. Fig. 1 represents an entire specimen, with a piece of column and perfect arms; the arms branch off from the second brachial, and are long, composed of wedge-form plates, which give off on alternate sides a row of strong pinnulæ, such as are found in *Poteriocrinus*. The specimen shows one side and partly the anterior of the body, for the ray at the extreme right has apparently more brachials than the other four, which is a very common occurrence in *Poteriocrinus*. Anal plates are not visible in the specimen, being probably imbedded in the rock. The second specimen, Fig. 28, is not sufficiently intelligible. The posterior side is shown, but the arrangement of the anal portion is so obscure that it gives no information whatever. The form of the calyx is like *Poteriocrinus*, subconical, and resembling Fig. 1.

The third specimen, Figs. 29 and 30, from the Ashmolean collection of Oxford, gives only the calyx, but this is sufficient to show that it is an entirely different form from that represented by Figs. 1 and 28. The position of the plates, the form of the calyx with strongly convex sides, the peculiar articulating facet of the first radials, their proportions, and the arrangement of the anal area, agree in every respect with Miller's generic diagram,[1] and with those species which we have mentioned as having no pinnulæ. On the other hand, the first two figures in the subconical form of the calyx, in the disposition and form of the plates, in having two additional brachials in the anterior ray, in the presence of pinnulæ, closely resemble *Poteriocrinus*. This has induced us to consider the Ashmolean specimen alone[2] to be *Cyathocrinus planus* and the type of the genus, and we propose an amendment of the generic formula so as to admit only those species that are without pinnulæ, making the latter one of the best distinctions between this genus and *Poteriocrinus*. The truncated posterior basal, the number and disposition of the anal plates, and the regular alternate arrangement of basals and radials are also excellent characters by which the two genera may be easily distinguished; but not the construction of the vault, nor the presence or absence of a separate buccal aperture, as Austin and De Koninck suggested; for both genera have a similar low vault with a single aperture, and in both types the ventral sac is lateral, strong, and upright, instead of extending from the entire summit like an enormous proboscis, as it has been described by several authors. De Koninck and Lehon give the number of anal plates at two to six, but there is really but one plate that can be regarded as such, all succeeding ones forming a part of the ventral sac.

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[1] Miller's diagram of the Ashmolean specimen, Fig. 30, appears at first sight to be very different from the generic diagram of the preceding plate, but it must be understood that the four small plates, arranged in the figure in a half circle, are to represent the interradials (oral plates) in the dome, and not the plates of the ventral sac, as might be expected.

[2] We were not aware, when the above was written, that Austin, who examined most of Miller's original specimens, came to almost the same conclusion in regard to *C. planus* (Rec. & Foss. Crin., p. 2). He remarks that Miller in some cases has taken "parts of different animals and jumbled them together" to render his figures as perfect as possible, and on page 59 he says: "Miller's principal figure of the *C. planus* cannot be depended on, as he appears to have taken the rays of *Taxocrinus longidactylus* and placed them on the body of *C. planus*." In supposing these to be the arms of *Taxocrinus*, Austin is certainly mistaken.

Hall, in order to admit into *Cyathocrinus* such types as were afterwards separated under *Barycrinus*, mentions in the Iowa Report that there sometimes occurs in the anal area a rather small intercalated plate; but this, though having a similar position, cannot be considered identical with the lower anal plate of *Poteriocrinus*. *Barycrinus* has been very generally accepted as a genus, and as the plate in question has only been observed in species of that type, it need no longer be considered in this connection.

Angelin, in the Iconographia Crinoideorum, p. 22, mentions the presence in *Cyathocrinus* of small pinnulæ. We have already noticed this point in the introductory remarks, and think we have proved that the two alternate rows of plates, there called pinnulæ, are merely plates which cover the ambulacral groove in the arms, and though they are, in our opinion, the homologues of the pinnulæ, they are too rudimentary to be ranked as such. The covering in *Cyathocrinus longimanus* Angl., from the Silurian, consists of two rows of five successive plates each, one row being given off from the right, the other from the left side of the furrow and perfectly covering it. In *Cyathocr. Iowensis* O. & Shum., from the Subcarboniferous, there have been observed only two successive plates arranged in the same manner. If it could be shown that this structure were constant in all Silurian species of *Cyathocrinus*, we should feel disposed to separate them from their subcarboniferous representatives, at least subgenerically, since in the former the arm-joints are comparatively shorter, the ventral tube stronger, and there is besides a peculiar difference in the general habitus of the two which is not easily expressed.

Sphærocrinus Roemer is founded upon *Cyathocrinus geometricus* Goldfuss, and it has all the characters of *Cyathocrinus*, not only in the construction of the calyx, but also of the vault, and we find a contraction of the body in the arm regions in the majority of its species.

Palæocrinus Billings is not distinct from *Cyathocrinus.* The construction of the calyx is identical, and the five calycinal grooves radiating from the centre of the abdominal surface, which, according to Billings, form the principal distinction, are identical with the ambulacral grooves passing here as there over the sutures of the oral plates. *Cyathocrinus*, especially in its Lower Silurian form, and when deprived of the arms, bears the closest relation to some forms of the Blastoids on one side, and the Pentacrinoid larva on the other. We propose the following:—

Revised Generic Diagnosis: General form of the body with arms, elongate; calyx cyathiform, usually with convex sides, incurving toward the upper margin, and, therefore, subglobose in general outline; symmetry bilateral.

Underbasals five, moderately large, of equal size, either spread out horizontally or with a slight upward curvature. Basals large, regularly alternating with the radials, with acute upper angles, except the posterior one which is truncate for the support of a single anal plate. Radials one by five, as large or larger than the basals, incurving toward the vault. Articulating facet rarely occupying more than one-half the width of the plate—often less than one-third—and one fourth to one-third its height. It is on the exterior of the plate, circular or elliptic in form, and provided either with a small perforation, or more frequently with a deep notch which connects with the arm groove. The brachials are similar in construction to the arm joints, and their number, as a rule, is very irregular, varying sometimes from two to seven in the same specimen, and even in arms of the same relative position, scarcely two rays having an equal number.

Arms long, branching, each branch bifurcating several times, and as they gradually taper toward the tips they become very slender above. The arm joints, as well as the brachials in Silurian species, are shorter, and comparatively heavier than in species from the Subcarboniferous. In the former they are about as wide as high, in their later representatives generally three or four times higher than wide. Both, however, agree in the absence of the pinnulæ and in the structure of the ambulacral groove, which, instead of those appendages, is provided with two rows of from two to five successive movable plates, alternately arranged on opposite sides, by means of which the furrow could be opened to the surrounding element, or shut off from it.

Anal plate one, resting upon the superior edge of the truncated basal and between two radials. None of the succeeding plates in the series are embraced in the calyx; they are much smaller and form a part of the ventral sac.

The vault is composed of five large oral plates, joining laterally, which fit in between the inflected margins of the two radial plates, leaving in the oral centre an open space, which in perfect specimens is completely covered by the apical dome plates. The food groove and ambulacral canal are also arched over solidly by two rows of alternate plates which connect with the movable covering of the arm furrow. The ventral sac extends to about one-half the height of the arms, and is composed of a large number of small plates not so regularly arranged as in *Poteriocrinus*. Its communication with the main body internally is maintained by means of a passage pierced through the posterior oral plate. The sac is stronger in the Silurian species, and in them only have pores and slits been observed.

Column round, with alternate larger and smaller joints in its upper portion; central passage scarcely of medium size.

Geological position, etc.—The genus existed in the Lower Silurian, was well represented in the Upper Silurian, and attained its greatest abundance in the Subcarboniferous. Beyond the age of the Keokuk limestone no trace of it has been discovered, and toward the close of that epoch the general aspect of the species underwent a marked change, the later species being large, and the arms, which before were delicate, became very robust at the bases. (See Wachsm. & Spr., Proc. Acad. Nat. Sci. Phila., 1878, p. 257.) According to Murchison and others, *Cyathocrinus* is represented in the Permian, but nothing has been discovered upon which to base this opinion beyond the fragments of columns, which afford no reliable proof. So far as ascertained there are 4 species from the Lower, 19 from the Upper Silurian; a single one from the Devonian; 28 from the Subcarboniferous, making in all 53 species, of which 27 have been found in Europe, and 26 in America.

1878. **Cyathocrinus acinotubus** Angelin. Iconogr. Crin. Suec., p. 23, pl. 20, fig. 5. Upper Silur. Gotland, Sweden.

1856. **Cyathocr. angulatus,** Billings. (**Palæocrinus angulatus.**) Geol. Surv. Can., p. 269; also Dec. iv. pl. 3, figs. 6 a, b. Trenton limest. Ottawa, Canada.

1878. **Cyathocr. alutaceus** Angelin Iconogr. Crin. Suec., p. 23, pl. 4, fig. 6, and pl. 23, figs. 10, 11. Upper Silur. Gotland, Sweden.

1865. **Cyathocr. arboreus,** Meek & Worth. Proc. Acad. Nat. Sci. Phil., p. 160; also Geol. Rep. Ill., vol. iii. p. 520. Keokuk limest. Subcarb. Crawfordsville, Indiana.

*1861. **Cyathocr. Barrisi** Hall. (**Poteriocr. Barrisi.**) Desc. New Pal. Crin., p. 5; also Bost. Jour. Nat. Hist., p. 303. Lower Burlington limest. Subcarb. Burlington, Iowa.

1878. **Cyathocr. barydactylus** Wachsmuth & Springer. Proc. Acad. Nat. Sci. Phil., p. 257, pl. 2, fig. 5. Upper Burlington Fishbed. Subcarb. Burlington, Iowa.

1836. **Cyathocr. bursa** Phillips Geol. Yorksh., vol. ii. p. 206, pl. 3, fig. 29; 1843, Austin, Mon. Rec. & Foss. Crin., p. 63, pl. 7, fig. 7 a. Subcarboniferous. Bolland, England.

1836. **Cyathocr. calcaratus** Phillips. Geol. Yorksh., p. 206, pl. 3, fig. 35; also Austin, 1843, Rec. & Foss. Crin , p. 63, pl. 8, fig. 2 a–c. Subcarbon. England.

1839. **Cyathocr. capillaris** Phillips. Murch. Silur. Syst., p. 671, pl. 17, fig. 2. Upper Silur. Dudley, England.

1836. **Cyathocr. conicus** Phillips. Geol. Yorksh , vol. ii. pt. ii. p. 206, pl. 3, fig. 27; also Austin, 1843, Rec. & Foss. Crin., p. 64, pl. 8, figs. 1 a, b. Subcarb. Bolland, England.

1868. **Cyathocr. cora** Hall. 18th Rep. N. Y St. Cab. Nat. Hist., p. 324, pl. 11, figs. 13, 14. Niag. group, U. Silur. Racine, Wisconsin.

1836. **Cyathocr. distortus** Gilbert. Phillips' Geol. Yorksh., vol. ii. p. 206, pl. 3, fig. 34. Subcarb. Bolland, England.

1878. **Cyathocr. distensus** Angl. Iconogr. Crin. Suec., p. 23, pl. 3, figs. 6, 6 a. Upper Silur. Gotland, Sweden.

*1843. **Cyathocr. Dudleyensis** Austin. (**Poteriocr. Dudleyensis.**) Upper Silur. Dudley, England.

1865. **Cyathocr. enormis** Meek & Worthen. (**Poteriocr. (?) enormis.**) Proc. Acad. Nat. Sci. Phil., p. 137; also Geol Rep. Ill , vol. iii. p. 481, pl. 16, figs. 3 a, b. Lower Burl. limest. Subcarb. Burlington, Iowa.

1866. **Cyathocr. Farleyi** Meek & Worthen. Proc. Acad. Nat. Sci. Phil., p. 252; Geol. Rep. Ill., vol. iii. pp. 5, 17, pl. 20, figs. 1 a, b. Keokuk limest. Subcarb Warsaw, Illinois.

1876. **Cyathocr. fasciatus** Hall. 28th Rep. N. Y. St. Cab. Nat. Hist., pl. 13, figs. 5, 6. (No description.) Niag. limest. U. Sil. Waldron, Indiana.

1868. **Cyathocr. fragilis** Meek & Worthen. Proc. Acad. Nat. Sci. Phil., p. 237; Geol. Rep. Ill., vol. v. p. 401, pl. 4, fig 5. Lower Burl. limest. Subcarb. Burlington, Iowa.

1826. **Cyathocr. geometricus** Goldfuss. Petref Germ., i. p. 189, pl. 58, fig. 5; Phillips, Pal. Foss., p. 135, pl. 60, fig. 41; Austin, Rec. & Foss. Crin., p. 61, pl. 7, figs. 5 a–e. F. Roemer. *Spærocrinus geometricus*, Verh. d. nat. Vereins f. Rheinl., viii. p. 366, pl. 8, fig. 1; Sandberger, Verst. Nassaus,

p. 390, pl. 25, fig. 14; Müller, *Poteriocr. geometricus*, Neue Echinod, d. Eifl. Kalkes, p. 250, pl. 2, figs. 4–7, and pl. 4, figs. 1–3. Schultze, Mon. Echinod, Eifl. Kalkes. p. 51, pl. 5, fig. 6 a to l. Schultze recognizes the following varieties: var., *typus*, pl. 5, fig. 6 a, b; var., *reticularis*, pl. 5, fig. 6 f, i; var., *ornata*, fig. 6 l; var., *ornata tuberculata*, fig. 6 k; var., *concentrica*. Devonian. Eifel, Germany.

Syn. *Poteriocrinus hemisphæricus*, Müller. Monatsber. d. Berl Acad. d. Wissensch. 1856, p. 354.

Syn. *Sphærocr. stellatus*, Schnur. Steininger's geognost. Beschr. d. Eifel. p. 38.

1878. **Cyathocr. Gilesi** Wachsmuth & Springer. Proc. Acad. Nat. Sci. Phil., p. 259. Fishbed, Upper Burl. limest. Subcarb. Burlington, Iowa.

1878. **Cyathocr. glaber** Angelin. Iconogr. Crin. Suec., p. 23, pl. 23, figs. 12, 13. Upper Silur. Gotland, Sweden.

1839. **Cyathocr. goniodactylus** Phillips. Murch. Silur Syst., p. 671, pl. 17, fig. 1. Upper Silur. Dudley, England.

*1879. **Cyathocr. Harrodi** n. sp. (For description see note below.)

1861. **Cyathocr. incipiens** Hall. Desc. New Pal. Crin., p. 5; Bost. Jour. Nat. Hist. 1861, p. 296. Upper Burl. limest. Subcarb. Burlington, Iowa.

1878. **Cyathocr. incurvatus** Angl. Iconogr. Crin. Suec., p. 23, pl. 24, fig. 1. Upper Silur. Gotland.

1850. **Cyathocr. Iowensis** Owen & Shumard. Journ. Acad. Nat. Sci. Phil. (2d ser.) vol. ii.; Geol. Surv. Wisc. Iowa and Minn., p. 591, pl. 5 A, figs. 11 a, b, c. Upper and Lower Burl. limest. Subcarb. Burlington, Iowa.

Syn. *C. divaricatus* Hall, 1858. Geol. Rep. Iowa, vol. i. pt ii. p. 554, pl. 9, fig. 5. (Young specimen.)

Syn. *C. malvaceus* Hall, 1858. Geol. Rep. Iowa, vol. i. pt. ii. p. 554, pl. 9, fig. 4 a, b. (Depressed specimen.)

Syn. *C. viminalis* Hall, 1861. Desc. New Pal. Crin., p. 5; Bost. Jour. Nat. Hist., p. 299. (See Wachsm. & Spr., Proc. Acad. Nat. Sci. Phil. 1877, p. 256.)

1863. **Cyathocr. lamellosus** White. Bost. Journ. Nat Hist., p. 504. Upper Burl. limest. Subcarb. Burlington, Iowa.

1878. **Cyathocr. lævis** Angelin. Iconogr. Crin. Suec., p. 23, pl. 26, figs. 2, 3. Upper Silur. Gotland, Sweden.

1878. **Cyathocr. longimanus** Angelin. Iconogr. Crin. Suec., p. 22, pl. 20, figs. 4, 6, 7, pl. 26, figs. 4, 5. Upper Silur. Gotland, Sweden.

1836 (?) **Cyathocr. mammillaris** Phillips. Geol. Yorksh., vol. ii. p. 206, pl. 3, fig. 28; Austin, 1843, Rec. & Foss, Crin. p. 64, pl. 7, fig. 8 a, b; De Koninck & Lehon, 1863, Recherches s. l. Crin. Carb. Belg., p. 82, pl. 1, fig. 4. Subcarboniferous. Bolland, England, and Visé, Belgium.

1878. **Cyathocr. monilifer** Angelin. Iconogr. Crin. Suec., p. 23, pl. 21, figs. 15, 15 a. Upper Silur. Gotland, Sweden.

1859. **Cyathocr. multibrachiatus** Lyon & Cassiday. Am. Jour. Sci., vol. 28. Keokuk limest. Subcarb. Crawfordsville, Indiana.

1878. **Cyathocr. muticus** Angelin. Iconogr. Crin. Suec., p. 23, pl. 21, figs. 22, 23. Upper Silur. Gotland, Sweden.

1836. (?) **Cyathocr. ornatus** Phillips. Geol. Yorksh., pt. ii. p. 206, pl. 4, figs. 36, 37. Subcarboniferous. Bolland, England.

1861. **Cyathocr. parvibrachiatus** Hall. Desc. New. Pal. Crin., p. 6; Bost. Journ. Nat. Hist., p. 294. Keokuk limest. Subcarb. Keokuk, Iowa.

1821. **Cyathocr. planus** Miller. A History of the Crinoidea, p. 85, figs. 29, 30 (*not* figs. 1 and 28); Austin, 1843; Rec. & Foss, Crin. p. 59, pl. 7, figs. 4 a–e. Subcarboniferous. Near Bristol, England.

1863. (?) **Cyathocr. polyxo** Hall. New sp. foss. from Niagara Gr. p. 5; and figured without description, 28th Rep. N. Y. St. Cab. Nat. Hist., pl. 15, figs. 10–17. Niagara limest. Upper Silur. Waldron, Indiana. (This is evidently not *Cyathocrinus*, but its generic relations cannot be ascertained from the material which has been discovered.)

1870. **Cyathocr. poterium** Meek & Worthen. Proc. Acad. Nat. Sci. Phil., p. 24; Geol. Rep. Ill., vol. v. p. 489, pl. 12, fig. 4. Keokuk limest. Subcarb. Crawfordsville, Indiana.

*1859. **Cyathocr. pulchellus** Billings. (**Palæocr. pulchellus.**) Geol. Surv. Can., Dec. iv. p. 46. Trenton limest. L. Silur. Ottawa, Can.

1878. **Cyathocr. ramosus** Angelin. Iconogr. Crin. Suec., p. 22, pl. 20, figs. 1–3. Upper Silur. Gotland, Sweden.

1856. (?) **Cyathocr. radiatus** Eichwald. (**Apiocrinus radiatus.**) Bull. Soc. des Nat. de Moscou, p. 115; Lethæa Rossica, p 592, pl. 31, figs. 50 a–f. Carboniferous. Near Moscow, Russia. (Perhaps *Poteriocrinus*—the figures not sufficiently intelligible.)

*1859. **Cyathocr. rhombiferus** Billings. (**Palæocrinus rhombiferus.**) Geol. Surv. Can., Dec. iv. p. 45. Trenton limest. L. Silur. Ottawa, Can.

1862. **Cyathocr. rigidus** White. Proc. Bost Soc. Nat. Hist., p. 8. Lower Burlington limest. Subcarb. Burlington, Iowa

1858. **Cyathocr. rotundatus** Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 555, pl. 9, figs. 7 a, b. Upper Burlington limest. Subcarb. Burlington, Iowa.

1826. **Cyathocr. rugosus** Goldfuss. Subcarboniferous. Saxony.

1860. **Cyathocr. saffordi** Meek & Worthen. Proc. Acad. Nat Sci. Phil., p. 371; Geol. Rep. Ill., vol. ii. p 236, pl. 17, figs. 5 a, b. Keokuk limest. Subcarb. Tennessee.

*1859. **Cyathocr. striatus** Billings. (**Palæocr. striatus.**) Geol. Surv. Can , Dec. iv. p. 25, pl. i. fig. 5 a, b Chazy limest. Montreal, Can.

1878. **Cyathocr. striolatus** Angelin. Iconogr. Crin. Suec., p. 23, pl. 19, fig. 9. Upper Silur. Gotland, Sweden.

1868. **Cyathocr. tenuidactylus** Meek & Worthen. Proc. Acad. Nat. Sci. Phil., p. 238; Geol. Rep. Ill., vol. v. p. 403, pl. 2, fig. 15. Lower Burlington limest. Subcarb. Burlington, Iowa.

1868. **Cyathocr. waukoma** Hall. 17th Rep. N. Y. St. Cab. Nat. Hist., p. 324, pl. 11, figs. 13, 14. Niagra Gr. Upper Silur. Racine, Wisconsin.

1878. **Cyathocr. zonatus** Angelin. Iconog. Crin. Suec., p. 22, pl. 6, fig. 5. Upper Silur. Gotland, Sweden.

NOTE.—*Cyathocrinus Harrodi*, n. sp. Form of calyx shallow, cup-shaped, the lower portion truncate and slightly excavated.

Underbasals very small, subquadrangular, spread out horizontally, and forming a five-rayed star. Basals large, a little wider than high, bending abruptly toward the underbasals in such a manner that the lower half of the plate stands on a level with the latter. The radials are of the size of the basals—perhaps a trifle smaller—once and a half as wide as high, subpentangular, the two lower sides making about a right angle. Articulating scar occupying about one-third the width of the plate, somewhat concave, and facing obliquely outward. Brachials varying from two to four or more in the rays, wider than high, rounded on the exterior, the upper one giving rise to two main arms, each of which branches three times.

Arms long, decreasing in width at each bifurcation, very delicate at the tips, the arm-joints increasing in length upward. Ventral furrow covered by two alternating rows of from two to three pieces. Anal plate small.

Surface of plates ornamented by strong radiating ridges, two to each radial, which connect with those of the two adjacent basals. They are most prominent on the latter, where they converge toward the middle into a node which points downward. These nodes, and their downward direction, give to the specimen an appearance very like *Ollacrinus*. Underbasals smooth.

Column small, round, composed of thin smooth joints, alternating in size; central perforation round.

This species is most nearly related to *C. lamellosus* White, of the Upper Burlington limestone, from which it differs in the number and form of the arms, which in our species are rounded, instead of sharply ridged on the back; in the surface markings of the calyx, and in the smooth column—that of *C. lamellosus* being beautifully sculptured.

The specific name is in honor of Dr. Harrod, of Canton, Ind., to whom we are indebted for the discovery and use of specimens.

Position and Locality. Keokuk limestone (Crawfordsville Division), Canton, Indiana, Collections of C. Wachsmuth and Dr. Harrod.

7. **LECYTHOCRINUS** Zittel (not Joh. Müller).

1858. *Lecythocrinus* Müller. Monatsber. der Berl. Akad., p. 196 (based upon an anomalous specimen).

1866. *Taxocrinus* Schultze. Echinod. d. Eifl. Kalkes, p. 30.

1879. *Lecythocrinus* Zittel. Handb. d. Petrefactenkunde (now in press).

Under this generic name, Johannes Müller described a species which, according to Schultze, was an abnormal specimen of his *Taxocrinus briareus*. In the original specimen, which is figured by Schultze, Mon. Echinod. d. Eifl. Kalkes, pl. 4, figs. 1 a–e, there are six radials and seven main arms, besides other irregularities in the calyx, plainly indicating some disturbance in the natural growth of the animal.

In the Am. Journ. Sci., Sept. 1877, one of us expressed a doubt as to *T. briareus* being a *Taxocrinus*, and we have since become convinced that its nearest affinities are with *Cyathocrinus* and *Gissocrinus*, from both of which it differs in the construction of the column, and in the small size of its underbasals. If the species possesses five underbasals, as we believe, it ought to be placed subgenerically under *Cyathocrinus;* if it has but three, as Schultze supposed (they have not been observed), it should be similarly ranked under *Gissocrinus*, but at all events under the Cyathocrinidæ.

Generic Diagnosis.—General form of the calyx cyathiform; symmetry bilateral.

Underbasals very small, entirely covered by the column, their number not ascertained. Basals five, four of them equal, the fifth or posterior one with the upper side truncate. Radials large, alternating with the basals; articulating faces concave, occupying one-half to two-thirds the width of the plate. Brachials two to four or more, their number varying in the different rays, as well as in different individuals. They are very short, the upper one supporting on each sloping side two main arms, which divide on the second or third plate, each division branching several times again.

Arms long, composed of simple joints, and provided with a dorsal canal[1] and a deep ambulacral furrow. No pinnulæ.

Anal plate one, constructed as in *Cyathocrinus* and resting upon the truncate posterior basal. Ventral sac in form of a long tube, constructed of numerous very regular hexagonal plates of equal height, longitudinally arranged in alternately wider and narrower rows.

The column, which forms the best generic distinction, is obtusely quadrangular, with slightly concave sides, and is composed of very narrow joints of equal size, which are penetrated by a large central and four smaller accessory canals, situated within the joints of the four angles.

The only known species is:—

*1866. **Lecythocrinus briareus** Schultze. Echinod. Eifl. Kalk., p. 36, pl. 4, fig. 1 (1858. **Locythocr. Eifelianus** Müller.); 1879. Zittel. *Lecythocrinus Eifelianus*, Handbuch d. Petrefactenkunde. 3te Liefer. (Now in press.) Devonian, Eifel, Germany.

8. **GISSOCRINUS** Angelin.

1878. Iconog. Crin. Suec., p. 10.

General form of body—including arms—elongate, slightly ventricose above the arm bases. Calyx low, neatly ornamented by radiating striæ; symmetry bilateral.

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[1] By "dorsal canal" we understand the longitudinal passage, which occurs in some forms through the calcareous joints of the arms, next to the dorsal side, and in connection with the nervous centre in the calyx.

Underbasals three instead of five, two of them equal and twice as large as the third; the smaller one placed anteriorly, the sutures of the two larger directed to the rear. The plates are so arranged that a bisection of the latter two produces five equal pieces regularly alternating with the succeeding ring of basals. Basals large, four of them pentagonal or hexagonal with sharp upper angles, the fifth longer, hexagonal, truncate above. Radials semi-lunate, larger than the basals, wider than long; articulating facet concave and occupying about one-half the width of the plate. The brachials consist either of a single bifurcating plate, which is wider than long, pentangular; or in some species of two smaller plates which combined have about the form and proportions of the single one.

Arms long, bifurcating, branches very numerous and of almost uniform thickness throughout their length. The divisions take place at regular intervals, but only toward the inner side of the ray, the outer or main arms remaining straight; the inner arms or branches remain simple or in some cases subdivide once or twice. The first bifurcation of the main arms takes place upon the first or second plate above the brachials, the next and all succeeding bifurcations from each first, second, or fourth plate, according to species. Arm-joints distinctly rounded on the exterior, with parallel sutures, rather higher than wide, the upper margin generally projecting into a band inclosing the lower part of the next plate. The axillary or bifurcating plates the largest, with a sharp angular process at their sides toward the upper margin. No pinnulæ. Arm furrows covered by two rows of alternate plates which stand out prominently forming an elevated arch.

Anal plate one, which is large, resting upon the truncate basal and supporting the ventral sac, which has the form of a tube. The tube is long, sometimes extending beyond the tips of the arms, rather strong; cylindrical except at its junction with the main body, where it becomes much contracted toward one side; the inner passage elliptic, almost linear in its cross section. It is composed of quadrangular plates longitudinally arranged, leaving a deep furrow between the rows lined with fissures which penetrate the test.

The construction of the summit closely resembles that of *Cya-*

thocrinus, except that the arms are recumbent upon the vault. There are five oral plates, upon the sutures between which, and raised above the general level, the arm-joints are imbedded, being covered by small alternating plates like the free arms.

Column round, composed of joints of alternating thickness.

Gissocrinus approaches nearest the Silurian form of *Cyathocrinus;* indeed the form of the calyx and the general aspect are strikingly similar. But they differ in the number of underbasals, which in this genus are reduced to three. Angelin places *Gissocrinus* with *Forbesiocrinus* and both under the Taxocrinidæ, which is certainly not a natural group. The long slender proboscis, the single ring of radials within the calyx, show clearly that this genus belongs to the Cyathocrinidæ.

Geological position, etc.—Upper Silurian of England and Sweden, so far as known.

The following species have been referred to it:—

1839. **Gissocrinus arthriticus** Phillips. (**Actinocr. arthriticus**), Murchison. Silur. Syst., p. 674, pl. 17, fig. 8, and Morris, Cat. Brit. Foss., Ed. 2, 1854, p. 70.—Salter, 1859. Murch. Siluria, Ed. 3, p. 535, pl. 14, fig. 7, and ibid. Ed. 4; p. 512; Salter, 1873, **Cyathocr. arthriticus,** Cat. Camb. and Silur. Foss. in Univ. of Cambridge, p. 124. Angelin. **Gissocr. arthriticus,** Iconogr. Crin. Suec., p. 10, pl. 3, figs. 1–3. Upper Silur. Gotland, Sweden, and Dudley, Eng.

1878. **Gissocr. elegans** Angelin. Iconogr. Crin. Suec., p. 10, pl. 3, fig. 5. Upper Silur. Gotland, Sweden.

1878. (?) **Gissocr. macrodactylus** Angelin. Iconogr. Crin. Suec., p. 10, pl. 18, fig. 1. Upper Silur. Gotland, Sweden.

This species differs from all others referred to this genus by Angelin in the brachials, which are represented in a greater number and variable as in *Cyathocrinus;* in the branching of the arms, and in having a more elongate calyx. The underbasals are said to be three, but this is not certain.

1878. **Gissocr. nudus** Angelin. Iconogr. Crin. Suec., p. 10, pl. 20, fig. 20. Upper Silur. Gotland, Sweden.

1878. **Gissocr. punctuosus** Angelin. Iconogr. Crin. Suec., p. 10, pl. 27, figs. 1 a–g; pl. 29, figs. 73–76. Upper Silur. Gotland, Sweden.

1878. **Gissocr. tubulatus** Angelin. Iconogr. Crin. Suec., p. 10, pl. 3, fig. 4. Upper Silur. Gotland, Sweden.

1878. **Gissocr. umbilicatus** Angelin. Iconogr. Crin. Suec., p. 10, pl. 21, figs. 8–10; pl. 29, figs. 75 a, b. Upper Silur. Gotland, Sweden.

9. **ARACHNOCRINUS** Meek & Worthen.

1866. Geol. Rep. Illinois, vol. ii. p. 177.

The above name, with *Cyathocrinus? bulbosus* Hall as type, was proposed by Meek and Worthen for a little group of Crinoids which are distinguished by their spider-like appearance. The calyx in these species, as compared with the long and robust arms, is extremely small, hemispherical, and forms a bulb-like protuberance, from which the arms spread horizontally. These characters distinguish this form readily from *Cyathocrinus*, with which it otherwise agrees, and they are so remarkable that we feel constrained to consider *Arachnocrinus* a distinct genus, and not a subgenus, as suggested by its authors.

We had lately the pleasure of examining the splendid collections of Dr. Knapp in Louisville, where we found two exceedingly interesting specimens, representing different species of this genus, both new. In one, the arms are almost closed, in the other spread out horizontally, thus demonstrating clearly that this Crinoid was capable of folding up its arms, and bringing them to an erect position, which has been doubted by Meek and Worthen, who could not conceive how an animal with so small a visceral cavity could have sufficient muscular power to move such ponderous arms. Dr. Knapp kindly permits us to describe the two species, which will be known as *A. Knappi* and *A. extensus*. Roemer's *Poteriocrinus pisiformis*, which Meek and Worthen refer to this genus, is but imperfectly known, but we do not doubt that the reference is correct. We also place in this genus *Cyathocrinus granulatus* Angelin, though it differs from the other species in the brachials, which are restricted to one to each ray. We propose the following:—

Generic Diagnosis.—Calyx very small, resembling *Cyathocrinus* in the arrangement of the plates, but more depressed; basal portion rounded. Arms exceedingly robust, generally stretched out horizontally, and arranged around the body, as the arms in *Astrophyton* around the disc.

Underbasals five, small, apparently of equal size. Basals five, the posterior one truncate. Radials wider than high, articulating scar occupying almost the entire width of the plate, and more or less concave. The number of brachials differs in the rays, as many as fourteen having been observed; they are cylindrical, wider than high, and resemble in form and construction the joints of the heavy arms.

Arms long, ramifying several times towards the inner part of the ray, the main arms and branches scarcely diminishing in size; in fact the joints near the tips of the arms are almost as large as the brachials. Both are generally short, quadrangular, except the bifurcating plates, which are comparatively longer. Ambulacral furrow deep. Pinnulæ wanting.

Anal plate one, small, resting upon the truncate basal, and supporting a lateral tube which is in line with the arm bases. The ventral tube was evidently small. In *A. Knappi* it apparently rests directly upon the basal, or probably the anal plate forms a part of the ventral sac. The vault is surmounted by five large oral plates—all other plates in the dome unknown.

Column round, of alternately larger and smaller joints.

Geological Position, etc.—Confined to the Upper Silurian and Devonian so far as known, and found both in Europe and America.

The following species may be referred to this genus:—

1860. **Arachnocrinus bulbosus** Hall. (*Cyathocr.* (?) *bulbosus*), 15th Rep. N. Y. St. Cab. Nat. Hist., p. 123, pl. 1, figs. 19–22. Upper Helderberg, Devon. Livingston Co., Kentucky.
*1879. **Arachnocr. extensus** Wachsm. and Spr. (See description below.[1])
*1878. (?) **Arachnocr. granulatus** Angelin. (*Cyathocr. granulatus*), Iconogr. Crin. Suec., p. 23, pl. 16, figs. 1–3 Upper Silur. Gotland, Sweden.
*1879. **Arachnocr. Knappi** Wachm. & Spr. (See description below.[2])

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[1] *Arachnocrinus extensus*, n. sp. The body of the only known specimen is not in a condition to exhibit satisfactorily the arrangement and proportions of all the plates, but enough is visible to show that the calyx closely resembles that of *Arachnocr. bulbosus.* Its plates are smooth, the underbasals small, and projecting but little beyond the column. Arms massive, bifurcating on the second brachial, except in the anterior ray which divides on the 14th or 15th plate, and branches further up four times; the two lateral rays branch five, the two posterior rays six times. The arms are long and stretched out horizontally to their full length. Arm joints almost as large as the brachials and like them cylindrical, much wider than long—except the bifurcating plates which are always comparatively longer, with a thickened rim both at their upper and lower margins.

This species differs from *A. bulbosus* in the proportions of its arm joints, from *A. Knappi* in the number of brachials, and from both in the bifurcation of the arms, ——. Hamilton Gr. below Hydraulic Beds (Encrinal limestone, Hall). Devonian, Falls of the Ohio.

[2] *Arachnocrinus Knappi*, n. sp. Calyx one and a half wider than high, basal portion concave. Underbasals small, not extending beyond the col-

*1860. **Arachnocr. pisiformis** Roemer. (*Posteriocr. pisiformis*), Sil. Fauna of West Tenn., p. 54, pl. 4, figs. 7 a–d; Meek & Worthen, *Arachnocr. pisiformis*. Geol. Rep. Ill., vol. ii. p. 177. Upper Silur. Tenn.

The arms are unknown in this species.

10. VASOCRINUS Lyon.

(Rectified by W. & Spr.)

1857. Geol. Surv. Kentucky, vol. 3, p. 485.

Hall—Advance Sheets Pal. New York, Vol. V., Part II., p. 6, containing a list of the Devonian fossils occurring at the falls of the Ohio—placed both species of Lyon's *Vasocrinus* under *Cyathocrinus*, in which he was apparently justified; for Lyon in describing the genus failed to point out any characters by which it might be distinguished from *Cyathocrinus*, except perhaps the peculiar form of the body. In his generic description Lyon mentions the presence of only a single anal plate, but at the same time describes his second species with two anals. On examining the original specimens, both of *V. valens* and *V. sculptus*, in the collection of Dr. Knapp, we arrived at the conclusion that Lyon was correct in separating these species from *Cyathocrinus*, and furthermore, that they are intimately related to certain other species

umn. Basals large, larger than the radials, and partly included within the concavity. Radials of unequal size—the posterior ones smaller—semilunulate; articulating facet strongly excavated, facing outward and almost circular in outline. Brachials very heavy, their number varying in the rays. In the original specimen the left posterior ray has fourteen brachials; the right posterior—evidently recuperated and hence perhaps not showing its normal condition—has eight; the lateral rays twelve to fourteen, and the anterior ray fourteen. The first and only bifurcation visible in the specimen takes place on the second, third, or fourth plate. Arms erect, being otherwise built upon the same plan as in *A. extensus*. Arm joints as heavy as the brachials, cylindrical, much wider than high, with parallel sutures, and without pinnulæ. All these plates appear as if constricted in the middle, on account of the thickening of the plates toward the sutures. Anal arrangement not clearly disclosed in the specimen, but there appears to be a rather large lateral opening directly above the posterior basal and between two adjoining radials. We can observe no special anal plate, and if it were present it was evidently small, and perhaps formed a part of the ventral tube, which toward the dome is supported by an elongate lozenge-shaped oral plate. Four additional oral plates of a similar form cover the ventral side. Apical dome plates, and the covering of the ambulacral furrow, not preserved. Hamilton Group. Devonian. Near Charleston, Indiana.

which have been referred to various genera and always with difficulty.

In reconstructing the genus, we prefer to make *Vasocrinus Lyoni* (*Cyathocrinus Lyoni* Hall), from Crawfordsville, the type, because it is found more perfectly preserved in the arm portion; but we scarcely doubt, to judge from the brachials, as far as they are preserved, that the arms in the Devonian species were constructed in a like manner.

Revised Generic Diagnosis.—Calyx shaped like a low vase; plates thin. Underbasals five, rather small, forming a regular pentagon. Basals large, almost as high as wide, generally depressed toward their angles, four pentagonal or hexagonal, the fifth with an additional side. Radials always wider than high, the upper portion strongly inflected toward the dome. Articulating facet, concave occupying about one-third of the plates, almost circular, deeply notched for the ambulacral groove. Brachials resembling the arm plates, but slightly wider. In *Vasocr. Lyoni*, the only species in which their number is perfectly known, there are two by five (*V. valens* had at least as many), with two arms to the ray.

Arms long, moderately heavy, tapering gradually to the tips. They are simple throughout, so far as observed, but in place of branching they throw off armlets alternately from each side, and these branch once or twice, as in *Botryocrinus* and *Barycrinus*, though they are less robust.

Anal area wide; anal plates generally two, rarely one, arranged as in *Barycrinus*. There is one large plate situated between two radials, and a smaller one placed obliquely toward the right side of the specimen, and between two basals, the right posterior radial and the larger anal. The ventral sac, as observed in *V. Lyoni*, extends to more than half the length of the arms. It is rather heavy, with a series of large quandrangular plates at the base,[1] the lower ones as wide, but much higher than the radials. All the other plates of the sac are much smaller, decreasing in size upward. Construction of the vault unknown.

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[1] These plates, which are much heavier and larger than any other plates of the tube, in their longitudinal arrangement and rounded exterior, strongly resemble an arm, and were taken by Lyon and Casseday,, who described this species as *Cyathocr. hexadactylus*, for arm plates of a sixth ray, and the large anal plate upon which they rest, for a radial.

Column round, undivided longitudinally (except in *V. dilatatus*); central perforation scarcely of medium size.

This genus occupies a position systematically between *Cyathocrinus* on the one side and *Botryocrinus* and *Barycrinus* on the other. It differs from *Barycrinus* in the delicacy of its body plates, in having two brachials instead of one, in the less robust arms, and in having a round column with a comparatively small and simply constructed passage, in contrast to the pentagonal, divided column, and wide and complicated central canal of that genus. From *Botryocrinus* it differs in the form of the ventral sac and the construction of the arms.

Geological Position, etc.—Devonian and Subcarboniferous; only found in America, save one doubtful species from the Eifel.

The following species are considered as belonging here:—

*1866. (?)**Vasocrinus dilatatus** Schultze. (**Poterior. dilatatus,** not Hall = **Coeliocr. dilatatus.**) Mon. Echinod. Eifl. Kalk., p. 49, pl. 5, figs. 3, 3 a. Devonian. Eifel, Germany.

This species has the column divided longitudinally, and therein approaches *Barycrinus*, from which it differs in having thin body plates, and a form exactly as in Lyon's typical species *V. valens*.

*1861. **Vasocr. Lyoni** Hall. (**Cyathocrinus Lyoni.**) Type of the genus. Desc. New. Pal. Crin., p. 5; Bost. Journ. Nat. Hist., p. 298. 1868. Meek & Worthen. **Barycrinus Lyoni.** Proc. Acad. Nat. Sci. Phila., p. 340. Keokuk limest. Subcarb. Crawfordsville, Indiana.

Syn. *Cyathocrinus hexadactylus*, Lyon & Casseday. 1859. Amer. Journ. Sci., p. 74.

Lyon's name has precedence, but being specifically as well as generically incorrect (see note above), we adopt Prof. Hall's later name.

*1861. **Vasocr. macropleurus** Hall. (**Cyathocr. macropleurus.**) Desc. New. Pal. Crin., p. 5; Bost. Journ. Nat. Hist., p. 295. Meek & Worthen, *Scaphiocr. macropleurus*. Geol. Rep. Ill., vol. v. p. 412. Lower Burl. limest. Subcarb. Burlington, Iowa.

1857. **Vasocr. sculptus** Lyon. Geol. Rep. Ky., vol. iii. p. 486, pl. 4, figs. 3 b–e.; Hall, 1877. *Cyathocr. sculptus*. Pal. N. Y., vol. v. (advance sheet No. 2) p. 6. Hamilton Gr., Devonian, above Hydraulic Bed. Jefferson Co., Ky.

1857. **Vasocr. valens** Lyon. Geol. Rep. Ky., vol. iii. p. 485, pl. 4, figs. 3, 3 a. Hall, 1877. *Cyathocr. valens*. Pal. N. Y., vol. v. (advance sheet No. 2) p. 6. Hamilton Gr. Devonian, above the Hydraulic Bed. Near Greenville, Ky.

11. **OPHIOCRINUS** Angelin.

1878. Iconogr. Crin. Suec., p. 24.

In the form and structure of the calyx this type resembles *Cyathocrinus*, but in the position of the arms it is like *Arachnocrinus*, from which it is perhaps only subgenerically distinct.

Underbasals five, four of medium size, equal, thin, upper edges meeting at right angles, except the fifth is truncated above. Radials five, lunulate; articulating surface deeply concave, and occupying almost the entire width of the plate. Brachials spreading out horizontally, varying in number from one to four in the different rays; very short but heavy. Only one anal plate.

Arms directed downward; composed of joints similar to the brachials, being, however, slightly narrower and longer. Total length of arms unknown. *O. crotalurus* had apparently only ten arms; in the original specimen some eight or nine arm joints are preserved without any signs of bifurcation. The arm grooves are rather narrow, covered by two rows of plates; with short lateral grooves given off from each side of the main furrow, within the arm joints, similarly covered, and which are evidently recumbent pinnulæ.

The condition of the ventral sac is the most remarkable feature of the genus. Instead of going straight upward, it bends close to the base, and coils upon itself spirally twice, decreasing in thickness toward the upper end. It is composed of regular rows of hexagonal plates alternately arranged, with a rather deep longitudinal ridge bordered with fissures on each side.

Column round, of alternate larger and smaller joints; central perforation of medium size.

This genus resembles *Cyathocrinus*, but is easily distinguished by its peculiar pendent arms, recumbent pinnulæ, and remarkable proboscis.

Geological position, etc.—Upper Silurian. Sweden.

The only known species is—

1878. **Ophiocrinus crotalurus** Angelin. Iconogr. Crin. Suec., p. 24, pl. 4, figs. 8 a–c. Upper Silur. Gotland, Sweden.

12. **BOTRYOCRINUS** Angelin.

1878. Iconogr. Crin. Suec., p. 24.

A. Typical form.

The crinoids of this type resemble in general form a tree with many branches and branchlets. Calyx small, cyathiform, unsymmetrical.

Underbasals five, slightly protuberant. Basals five, three of them equal, the other two of somewhat different form, due to their abutting against the anal plates. Radials large, articulating surface concave, occupying more than three-fourths of the width of the plate. Brachials less than one-half the size of the radials, wider than high, their number varying in the rays from two to five.

Each ray is composed of two main arms from which, throughout their entire length, spring two rows of branches, given off on alternate sides from every second or third joint, and which extend to the very top of the specimen. The secondary arms branch again, throwing off branchlets right and left, which themselves ramify, thus producing branches of a third and fourth order. The main arms are heavy, almost as wide at the base as the brachials, and decreasing in size very gradually toward the tips. The secondary branches are about two-thirds the size of the former, and those of the succeeding orders are slender, short, not reaching to the top of the specimen. The plates of arms and branches of corresponding position, throughout the specimen, are of equal width and height, those of the branches being relatively shorter. Articulating face of arm joints and brachials circular.

Anal plates two, arranged as in *Homocrinus;* the lower one rhomboidal, situated between two basals, the right posterior radial and the second anal. The latter is larger, similar in form to the radials, almost as large, and in line with them. Ventral sac of medium width, composed of very regular hexagonal plates, alternately arranged in rows. It is in form of a tube, and ascends almost vertically to about one-fourth the length of the arm, where it bends abruptly towards the posterior side and coils upon itself like a snail. Anal aperture apparently located anteriorly at the very base of the tube.

Vault composed of a large number of small plates the exact arrangement of which has not been ascertained.

Column round, composed of thin joints.

Botryocrinus agrees closest with *Barycrinus*, to the description of which we refer for comparison.

Geological position, etc.—Known only in the Upper Silurian of Sweden, where it is represented by the two following species:—

1878. **Botryocrinus ramosissimus** Angelin. Iconogr. Crin. Suec., p. 24, pl. 20, fig. 8 and Pl. 23, fig. 14. Upper Silur. Gotland, Sweden

1878. **Botryocr. corallum** Angelin. Iconogr. Crin. Suec., p. 24, pl. 15, fig. 9, and pl. 23, figs. 15, 16, and pl. 24, fig. 4.' Upper Silur. Gotland, Sweden.

B. Subgenus **SICYOCRINUS** Angelin.

1878. Iconogr. Crin. Suec., p. 23.

Sicyocrinus cucurbitaceus Angelin, the only known species of this type, is so closely related to *Botryocrinus* that we think it should be placed thereunder as a subgenus. The calyx, in form and arrangement of plates, is alike in both, and even the arms and ventral sac are constructed upon the same plan, but which is differently executed.

In *Sicyocrinus* there are five single arms, in place of five pairs, which give off branches from one side only, and not alternately from both sides as in the typical form. The branches, which are represented up to the fourth order, diverge from the arm at a less angle, and those of the third and fourth orders are comparatively longer. The brachials, as well as the arm joints throughout the branches, are from two to three and even four times longer than wide, and have a deep ambulacral furrow. The ventral sac, as in *Botryocrinus*, first ascends, then turns abruptly toward the posterior side, and bends until its extremity points downwards. It is now very remarkable that the portion of the tube which is bent over is not only firmly attached exteriorly to the lower part by a growth of plates, but it appears that its inner passage followed the curvature of the tube, for on each lateral surface there are two rows of fissures which follow exactly the line of deflection. Column obscurely pentagonal.

1878. **Sicyocrinus cucurbitaceus** Angelin. Iconogr. Crin. Suec., p. 24, pl. 4, fig. 9, and pl. 16, fig. 5. Upper Silur. Gotland, Sweden.

13 **BARYCRINUS** Wachsmuth.

(Diagram Pl. 1, Fig. 3.)

1868. Proc. Acad. Nat. Sci. Phil,. p. 338.

This genus was founded upon a group of Crinoids which had formerly been referred by Hall and Meek & Worthen to *Cyathocrinus*, differing, however, from it in several strongly marked features. In the first place the species are more robust, having thicker and more ponderous plates which form a more shallow cup. They also differ in having generally an extra quadrangular anal piece, which is inserted toward the right lower margin of the other anal, and although it is often very small, and in some rare cases entirely wanting, it is characteristic as a rule, while such a plate never occurs in *Cyathocrinus*. A more constant difference is observable in the brachials, which are proportionally shorter and wider, particularly the first one, which often presents an almost linear appearance. In *Cyathocrinus* the number of brachials is very irregular, but in *Barycrinus*, without exception, it is fixed at two. The best means of distinction, however, is afforded by the arms, which in *Barycrinus* are composed of rather short, heavy, rounded pieces, with very narrow ambulacral grooves, while *Cyathocrinus* has rather slender arms and wide, deep furrows. The arms also instead of regularly dichotomizing, so as to form equal divisions, are simple in *Barycrinus* and give off armlets at regular intervals. The column in this genus is almost unique in its construction, and very distinct from that of *Cyathocrinus*. It is not only stouter and subpentagonal, but is divided longitudinally into five sections, and has a large, highly organized central canal.

Barycrinus has its closest affinities with *Botryocrinus* Angl., with which it agrees in the general construction of the arms and in the anal arrangement, but from which it is easily distinguished by its massive body plates, the number and proportion of its brachials, and by the column.

Generic Diagnosis.—General form of the calyx basin or low cup-shaped; often attaining a gigantic size; plates massive, more or less gibbous or protuberant. Surface coarsely corrugated, granulated, or striated, with frequently a depression at each angle between the plates.

Underbasals five, of less than medium size, fully one-half extending beyond the column, their points in form of little triangles bent upward.

Basals large, three of them—sometimes four—hexagonal, the other two heptagonal. Radials five, very unequal in size, the right posterior and often the anterior one much the lowest, all of them wider than high, pentagonal in outline; articulating scar facing outward, concave, occupying from one-half to fully two-thirds the width of the plate. Brachials, two to each ray, wide and short, articulating face circular; the first one extremely short in the middle, one fourth as high as wide, and becoming still thinner or wedge-shaped at each side; the second is a little longer in proportion and presents a subtrigonal outline, supporting on its sloping upper sides two arms.

Arms moderately long, robust, scarcely decreasing in size, and generally simple throughout, though sometimes they branch once on the third or fourth plate in some of the rays—but never in the anterior one—and only in one arm to a ray, the other arm always remaining simple. In one species, probably *B. tumidus* Hall, from the Keokuk limestone, the antero-lateral rays are entirely simple, the arm plates and brachials forming a continuous series. All the main arms, instead of bifurcating, give off at regular intervals, alternately on opposite sides, and from the inner margins of the plates, short, rounded, simple armlets, which in most species throw off secondary branches as in *Botryocrinus*, and these armlets, here as there, probably performed the office of pinnulæ. The arm joints are simple, round, mostly shorter than wide, with a narrow, almost linear ambulacral furrow.

Anal plates generally two, never more. The lower plate which is often very small is wanting in some few species, and in very young specimens is frequently undeveloped, but when present, it is located against the posterior basal and beneath the right radial; the larger, which stands in line with the radial, is generally of about their height and half their width, quadrangular in outline. Ventral sac and vault unknown, but both were evidently of a delicate structure, as we have never seen a trace of them in any of our specimens.

Column short, obtusely pentagonal, divided longitudinally into five sections, which are in a radial position. The sutures are interradial, the opposite of *Heterocrinus* in which they are radial; they are bordered by little pores which apparently communicated with the large pentangular central canal at its five angles. These sutures extend throughout the entire length of the stem and partly to the radicular cyrrhi, which are strong, ramifying, and radially situated. The genus had evidently no cyrrhi along the column, for we have examined with reference to this point a number of specimens showing several feet of stem from near the body to, and including the root, without discovering any trace of them. The radicular cirrhi, which are long and strong, are given off radially.

The inner canal is large throughout and increases in size toward the root.

Geological position, etc.—The genus has a very limited range. It occurs so far as known only in the Subcarboniferous, and in America, where it first appears in the Lower Burlington limestone. It is found in the greatest profusion and size in the Keokuk, and has only two representatives in the Warsaw, where it becomes extinct.

We recognize 23 species, 2 of them being doubtful.

1860. **Barycrinus angulatus** Meek & Worthen. **(Cyathocr. angulatus.)** Proc. Acad. Nat. Sci. Phil., p. 391; Geol. Rep. Ill., vol. ii. p. 234, pl. 17, fig. 4; *Barycr. angulatus*, 1868, Proc. Acad. Nat. Sci. Phil., p. 340. Burlington and Keokuk transition bed. Subcarb. Nauvoo, Illinois (probably *syn.* of *B. sculptilis* Hall).

1858. **Barycr. bullatus** Hall. **(Cyathocr. bullatus.)** Geol. Rep. Iowa, vol. i. pt. ii. p. 624, pl. 18, fig. 1. *Barycr. bullatus* M. & W. 1868. Proc. Acad. Nat. Sci. Phil., p. 340. Keokuk limest. Subcarb. Keokuk, Iowa.

Syn. Cyathocr. protuberans Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 626, pl. 18, fig. 9.

1850. **Barycr. cornutus** Owen & Shumard. **(Cyathocr. cornutus.)** Jour. Acad. Nat. Sci. Phil. (2d ser.), vol. ii.; U. S. Geol. Surv. Wisc., Iowa, and Minn., p. 591, pl. 5, fig. 8 a, b; *Barycr. cornutus*, 1868. Proc. Acad. Nat. Sci. Phil., p. 340. Lower Burl. limest. Subcarb. Burlington, Iowa.

1860. **Barycr. crassibrachiatus** Hall. **(Cyathocr. crassibrachiatus.)** Supp. Geol. Rep. Iowa, p. 60; *Barycr. crassibrachiatus*, 1868. Proc. Acad. Nat. Sci. Phil., p. 340. Keokuk limest. Subcarb. Warsaw, Ill.

1873. (?) **Barycr. geometricus** Meek & Worthen. **(Cyathocr. ? undetermined.)** Geol. Rep. Ill., vol. iii. pl. 20, fig. 5 a–c; vol. v. pl. 12, fig. 3. Keokuk limest. Subcarb. Warsaw, Ill.

The original specimen is very imperfect, possibly *Nipterocrinus*.

*1868. **Barycr. herculeus** Meek & Worthen. **(B. Hoveyi var. herculeus.)** Proc. Acad. Nat. Sci. Phil., p. 341; Geol Rep. Ill., vol. v. p. 485, pl. 13, fig. 2. Keokuk limest. Subcarb. Crawfordsville, Ind.

This is a good species, and not a variety.

1861. **Barycr. Hoveyi** Hall. **(Cyathocr. Hoveyi.)** Desc. New. Pal. Crin., p. 5; Bost. Jour. Nat. Hist., p. 293; Meek & Worthen, 1873. *B Hoveyi*, Geol. Rep. Ill. vol. v. p. 486, pl. 13, fig. 1. Keokuk limest. Subcarb. Crawfordsville, Ind.

*1862. **Barycr. Kelloggi** White. **(Cyathocr. Kelloggi.)** Proc. Bost. Soc. Nat. Hist., p. 8. Keokuk limest Subcarb. Biggsville, Ill.

1858 **Barycr. magister** Hall. **(Cyathocr. magister.)** Geol. Rep. Iowa, vol. i. pt. ii. pl. 18, figs. 2, 3; *B. magister*, 1868, Proc Acad. Nat. Sci. Phil., p. 340. Keokuk limest. Subcarb. Keokuk, Iowa.

1868. **Barycr. magnificus** Meek & Worthen. Proc. Acad. Nat. Sci. Phil., p. 340. Geol. Rep. Ill , vol. v. p. 483, pl. 12, fig. 2. Keokuk limest. Subcarb. Biggsville, Ill.

1873. **Barycr. mammatus**[1] Worthen. Geol. Rep. Ill., vol v. p. 486, pl. 15, fig. 4. Keokuk limest. Subcarb. Otter Creek, Ill.

1873. **Barycr. pentagonus** Worthen. Geol. Rep. Ill., vol. v. p 487, pl. 15, fig 3. Keokuk limest. Subcarb. Jersey Co., Ill.

*1850. **Barycr. rhombiferus** Owen & Shumard. (**Poteriocr. rhombiferus.**) Jour. Acad. Nat. Sci. Phil., new ser., vol. ii. U S. Geol. Surv. of Wisc., Iowa, and Min., p 595, pl. 5 B, figs. 2 a, b, c. Lower Burl. limest. Subcarb. Burlington, Iowa.

1860 **Barycr. sculptilis** Hall. (**Cyathocr. sculptilis.**) Supp. Geol. Rep. Iowa, p. 59; *B. sculptilis*, 1868. Proc. Acad. Nat. Sci. Phil., p. 340. Upper Burl. limest. Subcarb. Burlington, Iowa.

Syn. Cyathocr. latus Hall, 1861. Desc. New. Pal. Foss., p. 5; and Bost. Jour., p. 292.

Syn. Cyathocr. scitulus Meek & Worthen, 1863. Proc. Acad. Nat. Sci. Phil., p. 393.

1861. **Barycr. solidus** Hall. (**Cyathocr. solidus.**) Desc. New Pal. Crin., p. 5. Bost. Jour. Nat. Hist., p. 293; *B. solidus*, 1868. Proc. Acad. Nat. Sci. Phil., p. 340. Upper Burl. limest. Subcarb. Burlington, Iowa.

1869. **Barycr. spectabilis** Meek & Worthen. Proc. Acad. Nat. Sci. Phil.; Geol. Rep. Ill., vol. v. p. 530, pl. 20, fig. 8. Warsaw limest. Subcarb. Jersey Co., Ill.

1858. **Barycr. spurius** Hall. (**Cyathocr. spurius.**) Geol. Rep. Iowa, vol. i. pt. ii. p. 625, pl. 18, figs. 7, 8; *B. spurius*, 1868. Proc. Acad. Nat. Sci. Phil , p. 340. Keokuk limest. Subcarb. Keokuk, Iowa.

*1858. **Barycr. stellatus** Hall. (**Cyathocr. stellatus.**) Geol. Rep. Iowa, vol. i. pt. ii. p. 623, pl. 16, figs. 3, 8. Keokuk limest. Subcarb. Keokuk, Iowa.

Syn. Cyathocr. quinquelobus Meek & Worthen, 1865. Proc. Acad. Nat. Sci. Phil., p. 150. Geol. Rep. Ill., vol. iii. p. 519, pl. 20, figs. 6 a, b.

1875. (?) **Barycr. striatus** Worthen. Geol. Rep. Ill., vol. vi. p. 515, pl. 29, fig. 5. Keokuk limest. Subcarb. Jersey Co., Ill.

This is certainly *not Barycrinus.* The lines of the sutures in the figure are drawn incorrectly, as, according to it, the basals are radial in position. It is most probably a *Dichocrinus.*

1865. **Barycr. subtumidus** Meek & Worthen. (**Cyathocr. subtumidus.**) Proc. Acad. Nat. Sci. Phil., p. 151, Geol. Rep. Ill., vol. v. p. 487, pl. 13, fig. 3; *B. subtumidus*, 1868. Proc. Acad. Phil. p. 340. Keokuk limest. Subcarb. Greene Co., Ill.

1860. **Barycr. Thomæ** Hall. (**Cyathocr. Thomæ.**) Supp. Geol. Rep. Iowa, p. 61; *B. Thomæ*, 1868. Proc. Acad. Nat. Sci. Phil., p. 340. Warsaw limest. Subcarb. Warsaw, Ill.

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[1] We are well aware that a number of these Keokuk species of *Barycrinus* are mere variations of earlier types, but as our material is too limited for comparison, we give them as they were described.

1858. **Barycr. tumidus** Hall. **(Cyathocr. tumidus.)** Geol. Rep. Iowa, vol. i. pt. ii. p. 624, pl. 18, figs. 1 b, c. *B. tumidus*, 1868. Proc. Acad. Nat. Sci. Phil., p. 340. Keokuk limest. Subcarb. Keokuk, Iowa.

1861. **Barycr. Wachsmuthi** Meek & Worthen. **(Cyathocr. Wachsmuthi.)** Proc. Acad. Nat. Sci. Phil., p. 136, Geol. Rep. Ill., vol. iii. p 482, pl. 16, fig 5; *B. Wachsmuthi*, 1868. Proc. Acad. Phil., p. 340. Lower Burl. limest. Subcarb. Burlington, Iowa.

14. POTERIOCRINUS, Miller.

1821. *Poteriocrinites* Miller. A History of the Crinoidea, p. 65.
1835. *Poteriocrinus* Agassiz. Mem. de la Soc. de Neuch., vol. i.
1836. *Poteriocrinus* Phillips. Geology of Yorkshire, p. 205.
1843. *Poteriocrinus* Austin. Rec. and Foss. Crin., p. 68.
1853. *Poteriocrinus* de Koninck & Lehon. Recher. s. l. Crin. Belg., p. 84.
1849. *Cupressocrinus* McCoy. Ann. & Mag. Nat. Hist., ser. ii. vol. ii. (not Goldf.).
1858. *Scaphiocrinus* Hall. (Subgenus of *Poteriocr.*) Geol. Rep. Iowa, p. 550. (Not *Graphiocrinus* de Koninck & Lehon.)
1866. *Poteriocrinites* Meek & Worthen. Geol. Rep. Ill., vol. ii. p. 179.
1866. *Scaphiocrinus* Meek & Worthen. (Subgenus of *Poteriocr.*) Ibid. vol. ii. p. 237.
1866. *Poteriocrinus* Schultze. Mon. Echinod. Eifl. Kalk. p. 42.
1867. *Hydriocrinus* Trautschold. Bull. de la Soc. Imp. des Naturalists de Moscou, p. 16.

(Diagram Pl. 2, No. 7.)

In no other genus of the Crinoids is there found so much confusion as in the one now under consideration. This is partly due to the imperfect preservation of the specimens from which the earlier descriptions were made, and also, no doubt, to the species themselves upon which Miller founded the genus. Neither of his two species of *Poteriocrinus* can be considered characteristic types of the genus, and unfortunately among his four species of *Cyathocrinus*—the genus with which *Poteriocrinus* was afterwards so often confounded—only one can be properly claimed for that genus, two of them having been later referred to very distinct groups, and the fourth is a *Poteriocrinus.*

According to Miller, the pelvis of *Poteriocrinus* is composed of five pentagonal plate-like joints, supporting five hexagonal intercostal plate-like joints, and five plate-like scapulæ with an intercostal and an interscapulary plate interposed; an arm proceeds from each scapula; column round, composed of narrow joints with a central perforation. This embraces everything in Miller's description which might be deemed of generic importance, but it is fully sufficient for identification, as it affords the means of separating this form from the only other genus of this family then known. It gives us unquestionable evidence of the existence of at least two anal plates within the calyx, which are plainly shown in the diagrams; while in Miller's typical species of *Cyathocrinus* only a single anal plate is mentioned or figured, which is wedged in between the scapulæ or first radial plates.

In the description of *P. crassus*, which is Miller's first species, and ought to be the type of the genus, he gives additional information regarding the scapulæ or radials. They are described as thin plates, obliquely truncated at the upper margins, excavated with a horseshoe-like impression occupying scarcely more than one-third the width of the plates. Miller's second species agrees well with the preceding. It has only one brachial, which is a bifurcating plate, narrow, four to five times longer than wide, supporting an arm on each side. Only one arm is preserved which has the same dimensions as the brachial, and a deep ambulacral furrow. Miller also found minute plates indicating that the abdominal cavity and perhaps also the excavated sulci in the arms were protected by a plated integument.

It thus appears that the calyx of *Poteriocrinus*, acccording to Miller, is composed of three rings of plates, 5 underbasals, 5 basals, and 5 radials; that there are not less than two anal plates, one alternating with the basals (intercostals) and another between the radials; that the radials in the two then known species are excavated for the attachment of the brachials, the articulating scar occupying only one-third the width of the plate; that in *P. tenuis*, the only species in which any part above the calyx was known, there is only a single brachial which is a very long, slender plate, and that the arm joints, so far as known, were found to be long and proportioned like the brachials. The calyx of both species is subconical, and both came from the Subcarboniferous of England. Miller describes the basals as being hexagonal, which is not quite correct. It was shown by de Koninck and Lehon that three of the subradials (basals) are hexagonal or heptagonal and of a similar form, while the other two—those in contact with the anal plates—have one or two additional sides, and are slightly larger. The same authors also point out the fact, that four of the radials are of equal size, pentagonal, regularly alternating with the basals, but that the right posterior one, which is rather smaller and elevated above the line of the others, is less regular in form and rests upon the truncated upper side of the basal and against the two anal pieces, differing therein from *Cyathocrinus*, in which basals and radials alternate all around. They consider the latter a very important distinction between the two genera, but they further assert that the best character for separation is to be found in the presence of a single aperture in the dome of *Poteriocrinus*, and of a separate oral and anal opening in *Cyathocrinus*. This unfortunate and altogether incorrect statement on the part of de Koninck has caused the utmost confusion, and when it was shown by Meek & Worthen that the supposed oral aperture is closed in perfect specimens in the one as well as in the other, some of the leading authorities in Europe, who had previously expressed their doubts as to the genus *Cyathocrinus*, wished to abandon it altogether. We, for our part, cannot endorse this proposition, for we think that the two genera are nicely defined by good generic characters; and that has been the opinion of the American Palæontologists generally, which has probably arisen from the fact that this country has produced far better specimens.

But while American authors agree thus far, they differ in regard to the proper limits of the genera. When in the course of recent years a great variety of forms of *Poteriocrinus* were discovered, Hall undertook to divide them subgenerically, but in this he was not very successful. In establishing his subgenus *Scaphiocrinus*, he selected *Scaphiocr.* (?) *simplex* as type, a species which in its anal arrangement and arm structure, though clearly distinct from *Poteriocrinus*, agrees exactly with *Graphiocrinus* de Koninck & Lehon. The majority of species, however, which were described under *Scaphiocrinus*, agree substantially, both in the arms and anal area, with *Poteriocrinus*, and we see no possibility of separating them. This may appear strange, for, on looking over a large collection of *Poteriocrinus*, it seems to embrace a number of very different groups; but an attempt to separate them will invariably result in finding but few species agreeing in the same points.

Hall defines *Scaphiocrinus* as follows: radials 2 × 5, both pentagonal, the first with the upper side straight or obliquely concave, the second with the lower side straight, often much elongated, and the plates contracted or concave on each side; anals four or more; arms double from their origin, or rarely simple in the anterior ray; arm plates simple, often wedge-shaped, with pinnulæ originating on the longer side of the plate; the line of articulation between first and second radials more or less gaping exteriorly, and the edge of the plate rounded. Among the species referred to *Scaphiocrinus* there are some with two brachials (three radials, Hall), others with but one; some with long slender brachials, others with short ones; some in which the brachials occupy the entire width of the upper margin of the radials, others scarcely one-third, and with a horseshoe-like articulating scar; some with a shallow almost concave calyx, others with a nearly cylindrical one; in some species the arms are simple, with short joints, in others branching, with long joints, or *vice versa;* in some the pinnulæ are strong, and the arms zigzag, in others thin and short, and the arms straight; but all agree, with the exception of the few species which we refer to *Graphiocrinus* (and among the latter Hall's *Scaphiocr. simplex*), in the construction of the anal area, which is exactly as described in *Poteriocrinus*, and in having a strong cylindrical or slightly club-shaped ventral sac.

Our own attempt to subdivide *Poteriocrinus* subgenerically met with but little better success, though we had the advantage of subsequent discoveries. A division based upon the number of free radials—or brachials as they are now called—cannot be carried out practically. Species with two brachials are not otherwise distinct from those with but one, and Hall himself, who founded *Scaphiocrinus* upon the presence of a single brachial, and likewise, Meek and Worthen, included therein several species with an additional brachial. In this they were evidently justified, for the additional plate, according to our views, is only a supplementary piece, which facilitates the motion of the arms, but has no effect upon the general structure of the animal. The two brachials combined have the form and size of the single one—in fact it is a compound plate, and this term properly expresses its relations.

Nor can the gaping sutures be regarded as of generic importance. We look upon this structure merely as another mode of articulation—taking place upon a straight hinge line instead of a sloping semicircular scar—and the gradations from one form to another are so close, that it is impossible to separate groups thereby. Nevertheless, to facilitate the identification of species, which is always difficult when there is a large number in a single group, we have separated *Poteriocrinus*, as well as could be ascertained from the descriptions and figures, with the aid of our own extensive collections, into six divisions, for which we propose distinct names. In doing so, however, we wish to have it understood that we scarcely deem the characters upon which they are based sufficiently important even for subgeneric separation. Still better distinctions may be discovered hereafter, and in the mean time this arrangement will prove very convenient for comparative study.

The genus *Poteriocrinus*, of which there are now over a hundred species known and described, was thought by Miller to be represented altogether by two, and of these the material at his command was very limited and imperfect, so that probably in order to make the most of what he had—to render his descriptions as perfect as possible and to prove some of his theories more effectually—he in some cases reconstructed the specimens from fragmentary pieces, which he supposed to be parts of the same species, but which, as we now know, belonged, at least in some instances, to different genera. The fact that Miller's figures cannot be relied upon, and that his best original specimens can nowhere be found (Austin), has produced continual trouble. Some of his species have been badly defined by subsequent writers. This is evidently the case with his typical species *P. crassus.* It is true Miller's figures are not so intelligible as might be wished, yet they prove plainly that the plates of the calyx in that species are thin, with elevations radiating from a point near the centre of the plates and meeting at the sutures those from adjoining plates. Such costæ—as these elevations have often been called—are found very prominent in several species of *Poteriocrinus* from the Burlington limestone, and in these they are not mere external markings, but are produced by a flexure of the plate itself. That the structure was similar in *P. crassus* is plainly indicated by Fig. 7 G, which represents folds on the inner surface of a radial—not intercostal, as Miller makes it. In the figures of de Koninck's so-called *P. crassus*, the plates, on the contrary, are massive, without plications, the surface simply granulose, and the articulating scar, which in Miller's specimens scarcely fills one-third the width of the radials, extends almost the entire breadth of the plate. Strange as it may appear, it seems as if de Koninck took the plications—which in Miller's principal figures somewhat indistinctly resemble the parasitic excrescences of one of his own specimens—to be the work of parasites; and in no other way can we account for his supposing such distinct forms to belong to the same species. The same difficulty exists in regard to Austin's figures, who has represented under *P. crassus* two or more distinct species.

The identification of *P. tenuis*, Miller's second species, is equally doubtful, and in our opinion altogether unreliable. The arms as there figured certainly do not belong to that calyx nor that column, and we are confident that the two latter pertain to *Poteriocrinus* and the former to *Cyathocrinus*. We may here remark that while we have experienced scarcely any difficulty in referring the known species to *Poteriocrinus* and *Cyathocrinus* respectively, we find in all of Miller's species, in one way or another, characters altogether at variance with the rules we have laid down for distinguishing the two genera. Under these circumstances the question arises whether it is not in the interest of science to adopt a new or at least an additional type for the genus. This may somewhat conflict with the rules and practices of naturalists, but in this case we consider it the only adequate remedy. We accordingly propose for this purpose *Poteriocrinus notabilis* Meek & Worthen, from the Burlington limestone, the original of which, formerly in the collection of C. W. and now in the Museum of Comp. Zool. of Cambridge, Mass., is figured in the Geol. Rep. Ill., vol. v., pl. 1, fig. 9. We have selected this species because it is found in very perfect preservation, and because it agrees most closely with Miller's typical species, and certainly belongs to the same division.

Making this the typical form, we further propose as sections under it *Scaphiocrinus* Hall, with *S. dichotomus* Hall's second species (the first being referred to *Graphiocrinus*) for type; *Parisocrinus* W. & Spr., with *Poteriocr. perplexus* M. & W.; *Pachylocrinus* W. & Spr., with *Poteriocr. subæqualis* W. & Spr. (Hall's *Poteriocr. æqualis*); *Scytalocrinus* W. & Spr., with *Poteriocr. robustus* Hall, *Decadocrinus*, with *Scaphiocr. scalaris* M. & W., respectively as types; and as we regard these sections rather as variations of the genus, which hardly rise to the dignity of subgenera, we shall for the present write the names with that of the parent genus prefixed. There are some other species, only known from the calyx which could not be satisfactorily arranged under the above groups, and these will be found in a list by themselves.

Generic Diagnosis.—General form of body with arms, elongate, subcylindrical, expanding uniformly upward. Calyx very variable in shape, subconical or subturbinate, sometimes bell, cup, or almost saucer-shaped; arrangement of plates unsymmetrical.

Underbasals five, equal in form and size, forming a more or less depressed pentagonal cup. Basals five, three of them hexagonal or heptagonal, and of the same size, the two others—those adjacent to the anals—slightly larger, and with one or two additional sides. Radials wider than high, four of a similar pentagonal form, and alternating regularly with the basals; the fifth slightly smaller, elevated above the level of the others, less regular in form, resting upon the truncated upper side of one basal and against two anal pieces. Articulating surface very variable, the scar for the attachment of the brachials occupying in the typical species scarcely one-third of the upper edge, but in some species it extends across the entire margin of the radials with a hinge-like apparatus for articulation. Brachials one to two or more, their number the same in four of the rays, the anterior having often a few additional plates. In species with only one brachial it is generally long and laterally constricted; in those with two brachials, the first is quadrangular and short, and both combined are equivalent in form and size to the single plate of the other type.

Arms simple or branching; the anterior ray, frequently less developed than the others, is sometimes simple throughout; composed of single joints, generally at least as high as wide, often much higher, more or less wedge-shaped, and throwing off pinnulæ alternately. In species whose pinnules have a decidedly zigzag arrangement they are remarkably strong.

Anals three (rarely four) within the calyx, in two rows alternately arranged; the lower one pentagonal, resting against the sloping upper side of the posterior basal and the radial to the right; the second supported by the upper truncated side of the posterior basal, having on the left a radial, on the right the first and third anal plates, the third being sometimes partly above the level of the calyx. Succeeding plates hexagonal, decreasing in size upwards, forming a part of the ventral sac. Ventral sac upright, strong, cylindrical, sometimes club-shaped, either extending up to the top of the arms or more than half way, frequently crowned with a set of long spines. Plates of the sac hexagonal, and pierced at the sutures with pores or fissures, which penetrate the lateral margins of the plates. Anal opening rarely observed, but in all cases, so far as known, low down and situated laterally, not posteriorly.

Dome constructed like that of *Cyathocrinus.* Apical dome plates frequently pushed toward the front by the large ventral sac.

Column round or pentagonal, composed of thin joints with a small central aperture.

Geological position, etc.—*Poteriocrinus* has not been found in the Silurian, neither in this country nor in Europe; the few species which were recorded from that age having since been referred to *Dendrocrinus*, *Homocrinus*, etc. It flourished to some extent in the Devonian, but reached its climax both in variety of form and number of individuals in the Subcarboniferous. There are known 17 species from the Devonian and 99 from the Subcarboniferous, of which 27 are from Europe and 89 from America. The species are arranged under the respective sections as follows:—

A. Typical form.

Calyx obconical, plates delicate, with elevated wrinkles or radiating plications. Radials with a semicircular scar facing outward, and deeply notched, not filling the full width of the plate. Brachials one by five, long, laterally constricted in the middle. Sutures somewhat gaping. Arms long and branching. Ventral sac very long and heavy. Column round.

1866. **Poteriocrinus angulosus** Schultze. Echinod. Eifl. Kalk., p. 50, pl. 5, figs. 3, 3 a. Devonian. Eifel, Germany.

1821. **Poteriocr. crassus** Miller. (Miller's type of the genus.) Nat. Hist. Crin., p. 68, with figures; Schlottlein, 1822. Nachtr. Petrefactenkunde, vol. i. p. 82; *Id.*, vol. ii. p. 93, pl. 25, fig. 2; Blainville, 1834. Mon. de Actin., p. 260, pl. 29, fig. 1; L. Agassiz, 1835. Mem. de la Soc. de Neuch., vol. i. p. 197; Milne Edwards, 1836. Lamarck's Anim. s. vert., 2d ed., vol. ii. p. 664; DeKoninck, 1842. Desc. des Anim. Foss. du Terr. Carb., p. 46, pl. F. fig. 4; Austin, 1843. Rec. and Foss. Crin., p. 69, pl. 8, figs. 3 a–k, and pl. 9, fig. 1; De Koninck and Lehon, 1853. Recherch. s. les Crin. Belg., p. 97, pl. 1, fig. 10 a–d. Subcarb. Yorkshire, England, and Visé, Belgium.

It is very doubtful whether specimens figured by these various authors represent the same species. De Koninck refers Austin's figures, pl. 8, fig. a–f and pl. 9, fig. 1, to *Pot. spissus*, while he himself figures a specimen which very probably belongs to *Barycrinus.* See our remarks on the genus.

*1861. **Poteriocr. doris** Hall. (**Scaphiocr. doris.**) Desc. New. Pal. Crin., p. 7, Bost. Journ. Nat. Hist., p. 310. Upper Burl. limest. Subcarb. Burlington, Iowa.

*1869. **Poteriocr. notabilis** Meek and Worthen. (**Scaphiocr. notabilis.**) Proposed type of the genus. Proc. Acad. Nat. Sci. Phila., p. 148. Geol. Rep. Ill., vol. v. p. 410, pl. 1, fig. 9. Lower Burl. limest. Subcarb. Burlington, Iowa.

1862. **Poteriocr. obuncus** White. Proc. Bost. Soc. Nat. Hist., p. 11. Lower Burl. limest. Subcarb. Burlington, Iowa.

1842. **Poteriocr. plicatus** Austin. Ann. and Mag. Nat. Hist. (ser. 1), vol. x. p. 108; *Id.*, vol. xi. p. 196. Mon. Rec. and Foss. Crin., p. 79, pl. 9, figs. 4 a–f; DeKoninck and Lehon, Recherch. Crin. Belg., p. 100, pl. 1, fig. 11. Subcarb. Bristol, England, and Tournay, Belgium.

1854. **Poteriocr. spissus** DeKon. and Lehon. Recherd. s. les Crin. Belg., p. 100, pl. i. figs. 9 a, b. Subcarb. Avon, England.

1866. **Poteriocr. stellaris** Schultze. Mon. Echinod. Eifl. Kalk., p. 49, pl. 5, fig. 2. Devonian. Eifel, Germany.

*1861. **Poteriocr. Whitei** Hall. (**Scaphiocr. Whitei.**) Desc. New. Pal. Crin., p. 7, Bost. Journ. Nat. Hist., p. 306. Lower Burl. limest. Subcarb. Burlington, Iowa.

B. SCAPHIOCRINUS Hall (modified by W. & Spr.).

1858. *Scaphiocrinus* Hall (subgenus of *Poteriocr.*). Geol. Rep. Iowa, vol. i. pl. ii. p. 550.

1867. *Hydriocrinus* Trautschold, Bull. de. Moscou, p. 16.

Calyx obconical to semiovoid. Radials truncate above; brachials simple or compound, and similar in form to the radials, but truncate below; line of articulation straight, occupying the full width of the plate; sutures gaping. Column round, obscurely pentagonal, or even pentalobate.

a. Species with a Simple Brachial.

*1859. **Pot. (Scaphiocrinus) æqualis** Hall (not **Scaphiocr. æqualis** Hall, 1861, Bost. Journ. Nat. Hist., p. 316 = *Pot.* (*Pachylocrinus*) *irregularis*, W. & Spr.). Supp. Geol. Rep. Iowa, p. 63. Lower Burl. limest. Subcarb. Burlington, Iowa.

Syn. Scaphiocr. solidus M. & W. 1861. Proc. Acad. Nat. Sci. Phila., p. 60.

Syn. Scaphiocr. tenuidactylus M. & W. 1865. Proc. Acad. Nat. Sci. Phila., p. 156. Geol. Rep. Ill., vol. iii. pl. 18, fig. 10.

*1864. **Pot. (Scaphiocr.) corycea** Hall. (**Pot. corycea**) 17th Rep. N. Y. St. Cab., p. 57. Geol. Sur. Ohio, Pal., vol. ii. p. 173, pl. 12, fig. 9. Waverly Gr. Subcarb. Richfield, Ohio.

1869. **Pot. (Scaphiocr.) coreyi** Meek & Worthen (not **Pot. coreyi**, Worthen. Geol. Rep. Ill., vol. vi. p. 514 = *Pot. Scytalocrinus grandis*, W. & Sp.). Proc. Acad. Nat. Sci. Phila., p. 148. Geol. Rep. Ill., vol. v. pl. 15, fig. 1. Keokuk limest. Subcarb. Crawfordsville, Ind.

1864. **Pot. (Scaphiocr.) crineus** Hall. 17th Rep. N. Y. St. Cab., p. 56. Geol. Surv. Ohio, Pal., vol. ii. p. 172 pl. 12, figs. 6, 7. Waverly Gr. Subcarb. Richfield, Ohio.

1858. **Pot. (Scaphiocr.) dactyliformis** Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 670, pl. 17, fig. 6. St. Louis limest. Subcarb. St. Louis, Mo.

1869. **Pot. (Scaphiocr.) delicatus** Meek & Worthen. Proc. Acad. Nat. Sci. Phila., p. 144; Geol. Rep. Ill., vol. v. p. 407, pl. 1, fig. 10. Upper Burl. limest. Subcarb. Burlington, Iowa.

1860. **Pot. (Scaphiocr.) divaricatus** Hall. Supp. Geol. Rep. Iowa, p. 65. Warsaw limest. Subcarb. Illinois and Indiana.

1858. **Pot. (Scaphiocr.) dichotomus** Hall. (Type of **Scaphiocrinus**, as proposed by us.) Geol. Rep. Iowa, vol. i. pt. ii. p. 553. Upper Burl. limest. Subcarb. Burlington, Iowa.

1873. **Pot. (Scaphiocr.) Huntsvillæ** Worthen. Geol. Rep. Ill., vol. v. p. 534, pl. 20, fig. 1. St. Louis limest. Subcarb. Huntsville, Ala.

*1860. **Pot. (Scaphiocr.) Keokuk** Hall. (**Poteriocr. Keokuk.**) Supp Geol. Rep. Iowa, p. 64. Keokuk limest. Subcarb. Keokuk, Iowa.

1858. **Pot. (Scaphiocr.) internodius** Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 679, pl. 25, fig. 2. Chester limest. Subcarb. Chester, Ill.

*1843. **Pot. (Scaphiocr.) isacobus** Austin. (**Poteriocr. isacobus.**) Ann. and Mag. Nat. Hist., vol. ii p 195. Mon. Rec. and Foss. Crin., p. 74, pl. 8, fig. 4 a, b. Subcarb. England and Ireland.

1869. **Pot. (Scaphiocr.) nanus** Meek & Worthen (not **Poteriocr. nanus**, Ad. Roemer, 1868 =*Homocrinus nanus*). Proc. Acad. Nat. Sci. Phila., p. 141; Geol. Rep. Ill., vol. v. p. 423, pl. 1, fig. 8. Lower Burl. limest. Subcarb. Burlington, Iowa.

1869. **Pot. (Scaphiocr.) penicillus** Meek & Worth. Proc. Acad. Nat. Sci. Phila., p. 142. Geol. Rep. Ill., vol. v. p. 414, pl. 2, fig. 7. Upper Burl. limest. Subcarb. Burlington, Iowa.

*1867. **Pot. (Scaphiocr.) pusillus** Trautschold (**Hydriocrinus pusillus**). Bull. de la Soc. Imp. des Naturalists de Moscou, p. 16, pl. ii. fig. 9; Quenstedt. Petrefact. Deutschlands, iv. p. 527, pl. 108, fig. 47. Trautschold, 1879, Kalkbrüche von Mjatschkowa, p. 116, pl. 14, fig. 4, and pl. 15, fig. 2. Upper Subcarb. Near Moscow, Russia.

1861. **Pot. (Scaphiocr.) ramulosus** Hall. Bost. Journ. Nat. Hist., p. 307. Upper Burl. limest. Subcarb. Burlington, Iowa.

1873. **Pot. (Scaphiocr.) Randolphensis** Worthen. Geol. Rep. Ill., vol. v. p. 551, pl. 21, fig. 14. Chester limest. Subcarb. Chester, Ill.

1863. **Pot. (Scaphiocr.) rusticellus** White. Bost. Journ. Nat. Hist., p. 505. Upper Burl. limest. Subcarb. Burlington, Iowa.

1858. **Pot. (Scaphiocr.) scoparius** Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 680, pl. 25, fig. 3. Chester limest. Subcarb. Chester, Ill.

*1852. **(?)Pot. (Scaphiocr.) spinosus** Owen & Shumard (**Poteriocr. spinosus**). U. S. Geol. Surv. Wis., Iowa, and Min., p. 596, pl. v B, fig. 4. Chester limest. Subcarb. Grayson Co., Ky.

It is possible that this species belongs to *Hydreionocrinus*—the figure is very imperfect.

1864. **Pot. (Scaphiocr.) subcarinatus** Hall. 17th Rep. N. Y. St. Cab., p. 58; Geol. Surv. Ohio, Pal., vol. ii. p. 176, pl. 12, figs. 13, 14. Waverly Gr. Subcarb. Richfield, Ohio.

*1861. **Pot. (Scaphiocr.) subimpressus** Meek & Worthen (**Poteriocr. subimpressus**). Proc. Acad. Nat. Sci. Phila., p. 138. Geol. Rep. Ill., vol. iii. p. 485 pl. 18, fig. 1 a, b. Lower Burl. limest. Subcarb. Burlington, Iowa.

1869. **Pot. (Scaphiocr.) thetys** Meek & Worthen. Proc. Acad. Nat. Sci. Phila., p. 143. Geol. Rep. Ill., vol. v. p. 419, pl. 2, fig. 13. Upper Burl. limest. Subcarb. Burlington, Iowa.

1861. **Pot. (Scaphiocr.) unicus** Hall. Desc. New Pal. Crin., p. 8. Bost. Journ. Nat. Hist., p. 313. Geol. Rep. Ill., vol. v. pl. 15, fig. 5. Keokuk limest. Subcarb. Crawfordsville, Ind.

1861. **Pot. (Scaphiocr.) verticellus** Hall. 15th Rep. N. Y. St. Cab., p. 122. Hamilton Gr. Devonian. Ontario Co., N. Y.

b. Species with Compound Brachials.

*1861. **Pot. (Scaphiocr.) carinatus** Hall (not **Poteriocr. carinatus** M. & W. = **Pot. (Pachylocr.) liliiformis** M. & W.). Desc. New Pal. Crin., p. 8, Bost. Journ. Nat. Hist., p. 310. Upper and Lower Burl. limest. Subcarb. Burlington, Iowa.

1869. **Pot. (Scaphiocr.) clio** Meek & Worthen. Proc. Acad. Nat. Sci. Phila., p. 144. Geol. Rep. Ill., vol. v. pl. 1, fig. 10. Upper Burl. limest. Subcarb. Burlington, Iowa.

*1860 **Pot. (Scaphiocr.) cultidactylus** Hall (**Poteriocr. cultidactylus**). Supp. Geol. Rep. Iowa, p. 62. Lower Burl. limest. Subcarb. Burlington, Iowa.

*1843. **Pot. (Scaphiocr.) longidactylus** Austin (**Poteriocr. londactylus**) (not Shumard, 1855, nor McChesney, 1859). Mon. Rec. and Foss. Crin., p. 88; pl. 11. fig. 3 a. Subcarb. England.

1878. **Pot. (Scaphiocr.) Gibsoni** White. Proc. Acad. Nat. Sci. Phila., p. 31. Keokuk limest. Crawfordsville, Ind.

1878. **Pot. (Scaphiocr.) Gurleyi** White. Proc. Acad. Nat. Sci. Phila., p. 32. Keokuk limest. Crawfordsville, Ind.

*1857. **Pot. (Scaphiocr.) missouriensis** Shumard. First described as *Poteriocr. longidactylus* (Shumard, not Austin). Geol. Rep. Missouri, p. 188, pl. B, figs. a–c. St. Louis limest. Subcarb. St. Louis, Mo.

It differs from all other species in this group in having a single arm to each ray, the first bifurcation taking place at the tenth or twelfth plate.

*1867. **Pot. (Scaphiocr.) multiplex** Trautschold (**Poteriocr. multiplex**). Bull. de Moscou, No. 3, p. 6, pl. 2, figs. 1–8; also F. Roemer, Lethæa Geognost., pl. 40, fig. 11. Trautschold, 1879, Steinbrüche von Mjatschkowa, p. 112, pl. 14, fig. 2, and pl. 15, fig. 1. Upper Subcarb. Near Moscow, Russia.

1865. **Pot. (Scaphiocr.) Norwoodi** Meek & Worthen. Proc. Acad. Nat. Sci. Phila., p. 158. St. Louis limest. Subcarb. Hancock Co., Ill.

*1875. **Pot. (Scaphiocr.) proboscidialis** Worthen (**Poteriocr. proboscidialis**). Geol. Rep. Ill., vol. vi. p. 518, pl. 31, fig. 1. St. Louis limest. Subcarb. St. Louis, Mo.

*1860. **Pot. (Scaphiocr.) Swallovi** Meek & Worthen (**Poteriocr. Swallovi**). Proc. Acad. Nat. Sci. Phila., p. 394. Geol. Rep. Ill., vol. ii. pl. 16, figs. 4 a, b. Upper Burl. limest. Subcarb. Burlington, Iowa.

C. PARISOCRINUS W. & Spr.

(πάρισος resembling, κρῖνον a lily.)

Calyx obconical. Differs from the last group in having two or more brachials, which are short and rest within a small semicircular scar. Mode of articulation and branching of arms almost as in *Cyathocrinus*. Column round, rarely pentangular.

1858. **Poteriocrinus (Parisocrinus) curtus** Müller. Verh. d. nat. Verein f. Rheinl., xii. p. 80, pl. 10, figs. 2, 3. Neue. Echin. Eifl. Kalk., p. 230, pl. 2, fig. 3; Schultze, 1866, Echin. Eifl. Kalk. p. 46, pl. 5, fig. 5. Devonian. Eifel, Germany.

*1858. **Pot. (Parisocr.) intermedius** Hall (**Cyathocr. intermedius**). Geol. Rep. Iowa, vol. i. pt. ii. p. 627, pl. 18, fig. 10. Keokuk limest. Subcarb. Warsaw, Ill.

1861. **Pot. (Parisocr.) nereus** Hall. 15th Rep. N. Y. St. Cab., p. 121. Hamilton Gr. Devonian. Ontario Co., New York.

1869. **Pot. (Parisocr.) perplexus** Meek & Worthen. Type of this group (*Poteriocr.* (?) *perplexus*). Proc. Acad. Nat. Sci Phila., p. 138. Geol. Rep. Ill., vol. v. p. 405, pl. 2, fig. 12. Lower Burl. limest. Subcarb. Burlington, Iowa.

1821. **Pot. (Parisocr.(?)) quinquangularis** Miller (**Cyathocr. quinquangularis**). A History of the Crinoidea, p. 92, with figures. *Poteriocrinus* Austin, 1843 Ann. and Mag. Nat Hist., vol. 10, p. 108, and vol. 11, p. 196. Rec. and Foss. Crin., pl. 10, figs. 2 a–e. Subcarb. England and Ireland.

1843. **Pot. (Parisocr.) radiatus** Austin. Ann. and Mag. Nat. Hist., vol. 10, p. 108, and vol. 11, p. 196. Rec. and Foss. Crin., p. 79, pl. 10, figs. 1 a, b. Subcarb. Ireland, England, and Belgium.

1862. **Pot. (Parisocr.) salignoideus** White. Proc. Bost. Soc. Nat. Hist., p. 10. Upper Burl. limest. Subcarb. Burlington, Iowa.

1861. **Pot. (Parisocr.) tenuibrachiatus** Meek & Worthen. Proc. Acad. Nat. Hist. Phila., p. 138. Geol. Rep. Ill., vol. iii. p. 485, pl. 16, fig. 1. Upper Burl. limest. Subcarb. Burlington, Iowa.

D. PACHYLOCRINUS W. & Spr.

(παχυλὸς thick, clumsy, κρῖνον a lily.)

Name given to designate the comparatively short (for *Poteriocrinus*), unusually stout aspect of the body. Calyx depressed; underbasals forming a concavity, and not extending beyond it; radials and brachials as in *Scaphiocrinus*, with straight hinge lines and gaping sutures; brachials generally compound. Arms short, and placed closely side by side, as in *Zeacrinus*, also dichotomizing in a very similar manner, but the arm joints are more cuneiform and angular on the exterior. Column round or obtusely pentagonal. *Pachylocrinus* is a kind of transition form toward *Zeacrinus* and *Cœliocrinus*, with which it agrees in the short and infolding arms and in the concavity of its basal portions; but it differs from both in the construction of the ventral sac, which in this group is almost cylindrical, with a tendency toward a balloon shape.

*1873. **Poteriocrinus (Pachylocrinus) arboreus** Worthen (**Zeacrinus arboreus**). Geol. Rep. Ill., vol. v. p. 534, pl. 20, fig. 5. St. Louis limest. Subcarb. Huntsville, Ala.

*1869. **Pot. (Pachylocr.) asper** Meek & Worthen. (**Zeacr. asper**). Proc. Acad. Nat. Sci. Phil., p. 150; Geol. Rep. Ill., vol. v. p. 430, pl. 1, fig. 7. Burl. limest. Subcarb. Burlington, Iowa.

1870. **Pot. (Pachylocr.) concinnus** Meek & Worthen. (**Pot. (Zeacr.) concinnus.**) Proc. Acad. Nat. Sci. Phil., p. 26; Geol. Rep. Ill., vol. v. p. 490, pl. 14, fig. 3. Keokuk limest. Subcarb. Crawfordsville, Ind.

1843. (?) **Pot. (Pachylocr.) latifrons** Austin. Rec. and Foss. Crin., p. 82, pl. 10, fig. 4. Subcarb. England (closely resembling *Zeacrinus*).

1869. **Pot. (Pachylocr.) liliiformis** Meek & Worthen. Described June, 1861, under *Pot. carinatus* M. & W. (not *Scaphiocr. carinatus* Hall, February, 1861), Proc. Acad. Nat. Sci. Phil., p. 139; *Scaphiocr. carinatus* M. & W., 1868, Geol. Rep. Ill., vol. iii. p 486, pl. 17, fig. 1; *Scaphiocr. liliiformis*, 1869, Proc. Acad. Nat. Sci. Phil., p. 138. Upper Burl. limest. Subcarb. Burlington, Iowa.

*1864. **Pot. (Pachylocr.) merope** Hall. (**Zeacr. merope.**) 17th Rep. N. Y. St. Cab., p. 60; Geol. Rep. Ohio, Pal, vol. ii. p. 178, pl. 12, fig. 18. Waverly Gr. Subcarb. Richfield, Ohio.

*1864. **Pot. (Pachylocr.) paternus** Hall. (**Zeacr. paternus.**) 17th Rep. N. Y. St. Cab., p. 59; Geol. Rep. Ohio, Pal., vol. ii. p. 177, pl. 12, fig. 17. Waverly Gr. Subcarb. Richfield, Ohio.

*1862. **Pot. (Pachylocr.) perangulatus** White. (**Zeacr. perangulatus.**) Proc. Bost. Soc. Nat. Hist., vol. ix. p. 11. Upper Burl. limest. Subcarb. Burlington, Iowa.

*1860. **Pot. (Pachylocr.) planobrachiatus** Meek & Worthen. (**Zeacr. planobrachiatus.**) Proc. Acad. Nat. Sci. Phil., p. 391; Geol. Rep. Ill., vol. ii. p. 240, pl. 18, fig. 5. Keokuk limest. Subcarb. Monroe Co., Ill.

*1879. **Pot. (Pachylocr.) subæqualis** Wachsm. & Springer. · Type of the group. Described by Hall, 1861, as *Scaphiocr. æqualis* (not *Pot.* (*Scaphiocr.*) *æqualis* Hall, 1859). Desc. New Pal. Crin., p. 8; Bost. Jour. Nat. Hist., p. 316; Meek & Worthen, 1873, Geol. Rep. Ill., vol. v. pl. 15, fig. 6. Keokuk limest. Subcarb. Crawfordsville, Ind.

E. SCYTALOCRINUS W. & Spr.

(*σϰυτάλγ* a staff or club; *ϰρῖνον* a lily.)

General form of body, including arms, very slender and almost cylindrical. Calyx obconical or bell shaped. Underbasals well developed and bent upward; radials and brachials of nearly the same form, with straight hinge line occupying the entire width of the plates; brachials either single or compound, and supporting on each side an arm which remains simple throughout; the anterior ray sometimes has but one arm. Arms long, composed of quadrangular or slightly cuneiform joints; pinnulæ of moderate size. Column round or obtusely pentagonal.

a. *Species with a Single Brachial.*

*1875. **Poteriocrinus (Scytalocrinus) abnormis** Worthen. (**Scaphiocr. abnormis.**) Geol. Rep. Ill., vol. vi. p. 519, pl. 31, fig. 6. St. Louis limest. Subcarb. Monroe Co., Ill.

1873. **Pot. (Scytalocr.) Bisselli** Worthen. Geol. Rep. Ill., vol. v. p. 546, pl. 21, fig. 4. Chester limest. Subcarb. Chester, Ill.

1843. **Pot. (Scytalocr.) dactyloides** Austin. Ann. and Mag. Nat. Hist., vol. x., p. 108; vol. xi. p. 197; Rec. and Foss. Crin., p. 86, pl. 10, fig. 7, and pl. 11, figs. 1 a, b. Subcarb. Ireland.

*1860. **Pot. (Scytalocr.) dactylus** Hall. (**Graphiocr. dactylus.**) Supp. Geol. Rep. Iowa, p. 80. St. Louis limest. Subcarb. Missouri and Illinois.

1860. **Pot. (Scytalocr.) decadactylus** Meek & Worthen. (Not **Cyathocrinus.** = **Poteriocr. decadactylus** Lyon & Cass. = **Scaphiocr. Coreyi** Worthen. = **Pot. (Scytalocr.) grandis** Wachsm. & Spr.) Trans. Acad. Nat. Sci. Phil., p. 394; Geol. Rep. Ill., vol. ii. p. 338, pl. 17, fig. 6. Keokuk limest. Subcarb. Illinois.

1858. **Pot. (Scytalocr.) decabrachiatus** Hall. Geol. Rep. Iowa, vol. i. pl. 2, p. 679, p. 25, fig. 1. Chester limest. Subcarb. Kaskaskia, Ill.
Syn. Scaphiocr. longidactylus McChesney, Dec. 1859, New Pal. Foss., p. 7; Trans. Chicago Acad. Sci., 1867, vol. i. pt. i. p. 4, pl. 4, fig. 4.

1865. **Pot. (Scytalocr.) Indianensis** Meek & Worthen. Proc. Acad. Nat. Sci. Phil., p. 155; Geol. Rep. Ill., vol. iii. p. 515, pl. 20, fig. 4. Keokuk limest. Subcarb. Crawfordsville, Ind.

This species, if not based upon an abnormal specimen of *P. robustus* Hall, differs from all the others in this section in having two brachials, and in having an additional arm in the posterior rays.

*1869. **Pot. (Scytalocr.) macrodactylus** Meek & Worthen. (**Scaphiocr. macrodactylus.**) Proc. Acad. Nat. Sci Phil., p. 140; Geol. Rep. Ill., vol. v. p. 415, pl. 2, fig. 9. Upper and Lower Burl. limest. Subcarb. Burlington, Iowa.

*1858. **Pot. (Scytalocr.) maniformis** Hall. (**Zeacrinus maniformis.**) Geol. Rep. Iowa, vol. i. pt. ii. p. 682, pl 25, fig. 8. Chester limest. Subcarb. Illinois. Kentucky and Tennessee.

This species shades into several genera, and cannot be satisfactorily brought under any of them. It agrees with *Graphiocrinus*, except in the anal area; the arm joints are like those of *Zeacrinus*, but the arms are simple instead of bifurcating; it agrees with *Eupachycrinus* in the form of the calyx and in the anal area.

1861. **Pot. (Scytalocr.) robustus** Hall. Descr. New Pal. Crin., p. 7. Bost. Jour. Nat. Hist., p. 315. Keokuk limest. Subcarb. Crawfordsville, Ind.
Syn. Poteriocr. Hoveyi Worthen. Geol. Rep. Ill., vol. vi. p. 516, pl. 29, fig. 6.
1843. **Pot. (Scytalocr.) rostratus** Austin. Ann. and Mag. Nat. Hist., vol. x. p. 108; vol. xi. p. 196; Rec. and Foss. Crin., p. 75, pl. 9, figs. 2 a–f. Mountain limest. Subcarb. England, Ireland.

1879. **Pot. (Scytalocr.) Wetherbeyi** Miller. Cincinnati Soc. Nat. Hist. (April number), p. 6, pl. 8, figs. 1, 1 a, b. Chester limest. Subcarb. Kentucky.

b. Species with a Compound Brachial.

1867. **Pot. (Scytalocr.) bijugus** Trautschold. Bull. Soc. Natur. de Moscou, p. 14, pl. 4, fig. 1–3. 1879. Kalkbrüche von Mjatschkowa, p. 114, pl. 14, fig. 3. Upper Subcarb. Moscow, Russia.

*1879. **Pot. (Scytalocr.) grandis** Wachsm. & Spr. Described as *Poteriocr. Coreyi* Worthen, 1875. Geol. Rep. Ill., vol. vi. p. 516, pl. 29, figs. 2, 3 (not *Pot.* (*Scaphiocr.*) *Coreyi* M. & W. 1869). Keokuk limest. Subcarb. Crawfordsville, Ind.

*1867. (?)**Pot. (Scytalocr.) originarius** Trautschold. Bull. Soc. Nat. de Moscou, p. 2, pl. 1, fig. 1. Kalkbrüche bei Mjatschkowa, p. 110, pl. 14, fig. 1. Upper Subcarb. Near Moscow, Russia.

We cannot believe that this species possesses only six arms as described by its author, as this would be too great a departure from the arm structure of Crinoids generally. It may possibly have had nine arms, with a single one in the anterior ray, but more probably ten. Thus far but a single specimen has been discovered, and in this only the right posterior ray is perfectly visible, which had two arms; the two adjoining rays are partly hidden from view, while the remaining two are entirely imbedded in the matrix. There are traces of but five arms in the slab. We judge from the photograph, Pl. 14, fig. 1, that the arrangement of the plates in the calyx has been somewhat disturbed, and this explains the fact that in the diagram, p. 110, the basals (subradials of Trautschold) and radials are incorrectly represented. It may, however, be possible that the original, like a specimen of *P. bijugus* in our possession, for which we are indebted to the kindness of Prof. Trautschold, is abnormal, and that some of the basals (subradials) are anchylosed with the adjoining radials, as in our specimen. Until better material is found we must consider *P. originarius* as a large and abnormal example of *P. bijugus.*

*1879. **Pot. (Scytalocr.) urna** Trautschold. (**Phialocr. urna**). Steinbrüche von Mjatschkowa, p. 123, pl. 15, fig. 5. Upper Subcarb. Near Moscow, Russia. (Compare with our remarks on *Phialocrinus.*)

1875. **Pot. (Scytalocr.) Van Hornei** Worthen. Geol. Rep. Ill., vol. vi. p. 517, pl. 31, figs. 2, 3. St. Louis limest. Subcarb. St. Louis, Mo.

F. DECADOCRINUS W. & Spr.

(δέκας number of ten; κρῖνον a lily.)

Arms always ten in number. Calyx depressed. Shallow bowl or saucer-shaped. Underbasals small, frequently hidden from view in the concave base. Form of radials and brachials as in the preceding group, the latter plates simple or compound. Arms composed of angular wedge-form joints, zigzag, with the longer sides alternating and projecting so as to support short rounded pinnulæ, which have the appearance of armlets. Column more or less pentangular.

a. Species with a Single Brachial.

*1865. **Poteriocrinus (Decadocrinus) Bayensis** Meek & Worthen. (**Scaphiocr. Bayensis.**) Proc. Acad. Nat. Sci. Phil., p. 157; Geol. Rep. Ill., vol. v. p. 550, pl. 20, fig. 2. Chester limest. Subcarb. Illinois.

*1870. **Pot. (Decadocr.) depressus** Meek & Worthen. (**Scaphiocr. depressus.**) Proc. Acad. Nat. Sci. Phil., p. 27; Geol. Rep. Ill., vol. v. pl. 14, fig. 8. Keokuk limest. Subcarb Crawfordsville, Ind.

*1869. **Pot. (Decadocr.) fiscellus** Meek & Worthen. (**Scaphiocr. fiscellus.**) Proc. Acad. Nat. Sci. Phil, p. 141; Geol. Rep. Ill., vol. v. p. 423, pl. 1, fig. 3. Lower Burl. limest. Subcarb. Burlington, Iowa.

*1861. **Pot. (Decadocr.) Halli** Hall. (**Scaphiocr. Halli.**) Desc. New Pal. Crin., p. 7; Bost. Journ. Nat. Hist., p. 308. Upper Burl. limest. Subcarb. Burlington, Iowa.

*1864. **Pot. (Decadocr.) lyriope** Hall. (**Scaphiocr. lyriope.**) 17th Rep. N. Y. St. Cab., p. 58; Geol. Surv. Ohio, Pal., vol. ii. p. 175, pl. 12, fig. 10. Waverly Gr. Subcarb. Richfield, Ohio.

1864. **Pot. (Decadocr.) pleias** Hall. 17th Rep. N. Y. St. Col., p. 141; Geol. Surv. Ohio, Pal., vol. ii. p. 173. Waverly Gr. Subcarb. Richfield, Ohio.

*1869. **Por. (Decadocr.) Stimpsoni** Lyon. (**Zeacr. Stimpsoni.**) Trans. Am. Philos. Soc., Phil., p. 465, pl. 27, fig. m, m 1. Subcarb. Kentucky.

b. Species with More than one Brachial.

*1864. **Pot. (Decadocr.) ægina** Hall. (**Saphiocr. ægina.**) 17th Rep. N. Y. St. Cab., p. 57; Geol. Rep. Ohio, Pal., ii. p. 174, pl. 12, figs. 11, 12. Waverly Gr. Subcarb. Richfield, Ohio.

1861. **Pot. (Decadocr.) diffusus** Hall. 15th Rep. N. Y. St. Cab., p. 121. Hamilton Gr. Devonian. Ontario Co., New York.

*1863. **Pot. (Decadocr.) gracilior** F. Roemer. (**Cyathocr. gracilior.**) Dunker's Palæontologr., vol. ix. p. 149, pl. 29, fig. 1; pl. 25, figs. 8, 10. Dachschiefer. Grauwacke. Bundenbach, Germany.

*1869. **Pot. (Decadocr.) juvenis** Meek & Worthen. (**Scaphiocr. juvenis.**) Proc. Acad. Nat. Sci. Phil., p. 146; Geol. Rep. Ill., vol. v., p. 417, pl. 2, fig. 8. Lower Burl. limest. Subcarb. Burlington, Iowa.

1861. **Pot. (Decadocr.) nycteus** Hall. 15th Rep. N. Y. St. Cab., p. 120. Hamilton Gr. Devonian. Ontario Co., N. Y.

*1861. **Pot. (Decadocr.) scalaris** Meek & Worthen. Type of this group (*Scaphiocr. scalaris*). Proc. Acad. Nat. Sci. Phil., p. 145. Geol. Rep. Ill., vol. v. p. 421, pl. 2, fig. 10. Upper Burl. limest. Subcarb. Burlington, Iowa.

*1864. **Pot. (Decadoc.) subtortuosus** Hall. (**Scaphiocr. subtortuosus.**) 17th Rep. N. Y. St. Cab., p. 59. Geol. Surv. Ohio, Pal., vol. ii. p. 177, pl. 12, figs. 15, 16. Waverly Gr. Subcarb. Richfield, Ohio.

G. Species of Poteriocrinus, imperfectly known.

1858. **Poteriocr. calyculus** Hall. Geol. Rep. Iowa, vol. i. pl. 2, p. 553, pl. 9, figs. 6 a, 6 b. Lower Burl. limest. Subcarb. Burlington, Iowa.

1836. **Poteriocr. conicus** Phillips. Geol. Yorksh., ii. pl. 4, fig. 3. Portlock's Geol. Rep., pl. 16, fig. 12. De Koninck, 1842, Animaux Foss., p. 47, pl. F, fig. 3; Milne Edwards ap. Lamark, p. 664; Austin, 1843, Rec. and Foss. Crin., p. 82, pl. 10, figs. 3 a, b, c. Subcarb. England, Ireland, and Belgium.

1853. **Poteriocr. conoideus** De Koninck & Lehon. Recherch. Crin. Belg., p. 93, pl. 1, figs. 8 a, b. Subcarb. Visé, Belgium.

1869. (?)**Poteriocr. cylindricus** Lyon. (Not Hall=**Homocr. cylindricus**). Trans. Am. Philos. Soc., Philad., vol. xiii. p. 458, pl. 27, fig. 1. Encrinal limest. Subcarb. Falls of the Ohio. (Imperfect specimen.)

1842. **Poteriocr. gracilis** McCoy. (Not **Pot. gracilis** Hall = **Dendocr. gracilis.**) Carb. Foss. Ireland, p. 178, pl. 25, figs. 11–14. Subcarb. Ireland.

1873. **Poteriocr. Hardinensis** Worthen. Geol. Rep. Ill., vol. v. p. 533, pl. 20, fig. 10. St. Louis limest. Subcarb. Hardin Co., Ill.

1836. **Poteriocr. impressus** Phillips. Geol. Yorksh., ii. p. 205, pl. iv. fig. 1; Austin, 1843, Rec. and Foss. Crin., pl. 10, fig. 6. (Not *Pot. impressus* Richter & Unger. Geognost. Rossica, 1860, pl. 31, fig. 46.) Subcarb. England.

1861. **Poteriocr. indentus** Hall. 15th Rep. N. Y. St. Cab., p. 122. Hamilton Gr. Devonian. Ontario Co., N. Y.

*1861. **Poteriocr. læviculus** Lyon. (**Cyathocr. læviculus.**) Proc. Acad. Nat. Sci. Phil., p. 409. Encrinal limest. Subcarb. Jefferson Co., Ky.

1875. **Poteriocr. Lasallensis** Worthen. Geol. Rep. Ill., vol. vi. p. 526, pl. 32, fig. 3. Upper Coal Measures. Lasalle, Ill.

1861. **Poteriocr. lepidus** Hall. Desc. New Pal. Crin., p. 6; Bost. Journ. Nat. Hist. p. 304. Lower Burl. limest. Subcarb. Burlington, Iowa.

1873. **Poteriocr. macoupiensis** Worthen. Geol. Rep. Ill., vol. v. p. 561, pl. 24, fig. 3. Coal Measures, Ill.

1850. **Poteriocr. minutus** F. A. Roemer. Beitr. zur Kenntn. d. Harzgeb., p. 47, pl. 8, figs. 1 a–d. Posidonien Schiefer. Devonian. Lauthenthal. Germany.

1872. **Poteriocr. montanaensis** Meek. Hayden's Rep. U. S. Geol. Surv. Terr. Lower Carbon. Montana Territory.

1861. **Poteriocr. nassa** Hall. 15th Rep. N. Y. St. Cab., p. 120. Hamilton Gr. Devonian. Canandaigua, N. Y.

1861. **Poteriocr. nereus** Hall. 15th Rep. N. Y. St. Cab., p. 121. Hamilton Gr. Devonian. Ontario Co., N. Y.

1861. **Poteriocr. nodobrachiatus** Hall. Desc. New Pal. Crin., p. 8; Bost. Journ. Nat. Hist., p. 614. Keokuk limest. Subcarb. Crawfordsville, Ind.

1858. (?)**Poteriocr. pachydactylus** Müller. Monatsber. Berl. Acad., p. 192. Devonian. Germany. (No means of comparison.)

1858. (?)**Poteriocr. patulus** Müller. Monatsber. Berl. Acad. Devonian. Germany. (No means of comparison.)

1843. **Poteriocr. pentagonus** Austin. (**Cladocr. pentagonus.**) Ann. & Mag. Nat. Hist., vol. ii. p. 198; Rec. and Foss. Crin., p. 86, pl. 11. figs. 2 a–f. Subcarb. England.

1858. **Poteriocr. rugosus** Shumard. Trans. St. Louis Acad. Sci. Coal Measures. (No means of comparison.)

1869. **Poteriocr. simplex** Lyon. (Not **Pot.** (**Scaphiocr.**) **simplex** Hall=**Graphiocr. simplex.**) Trans. Am. Philos. Soc. Phil., p. 458, pl. 26, fig. f. Upper Helderberg, Devonian. Falls of the Ohio.

1821. **Poteriocr. tenuis** Miller. Hist. Crin., p. 71; Schlotheim, 1822; Nachtr. Petrefactenk., vol. ii. pl. 25, fig. 2; Austin, 1843, Rec. and Foss. Crin., p. 83, pl. 10, figs. 5 a, b. Mountain limest. Subcarb. England and Ireland.

*1861. **Poteriocr. Wortheni** Lyon. (**Cyathor. Wortheni.**) Proc. Acad. Nat. Sci. Phil., p. 410. Encrinal limest. Devon. Jefferson Co., Ky.

15. GRAPHIOCRINUS De Koninck & Lehon.

1853. *Graphiocrinus* De Kon. & Leh. Crin. Carb. Belg., p. 115.
1858. *Scaphiocrinus* (in part) Hall. Geol. Rep. Iowa, vol. i. pt. 2, p. 549.
1879. *Phialocrinus(?)* Trautschold. Kalkbrüche Mjatch., p. 122.

A. Typical form.

In general aspect *Graphiocrinus* closely agrees with a form of *Poteriocrinus* for which we have proposed the name *Scytalocrinus*, from which, however, it differs clearly in the anal area, which in *Graphiocrinus* has but a single plate, while in the other it has three. De Koninck, in his generic description, mentions only two orders of plates as constituting the calyx, in which he is evidently mistaken. We have before us several species from the Burlington limestone, which have heretofore been referred by their authors to *Scaphiocrinus*, but which agree in the clearest manner with the typical *Graphiocrinus encrinoides.* They all, like the typical species, have ten arms—except an undescribed species, which we think belongs to this type, and which has only five—constructed of simple joints with parallel sutures; they have one large brachial and a single anal plate, extending beyond the general limit of the calyx; and whenever the column is attached there is no trace of underbasals, yet these plates are found in every one of those species when seen with the column removed. We can no longer doubt, from the evidence of our specimens, that the underbasals, as suggested by Hall and Meek & Worthen, are also present in the Belgian species, but hidden from view by the column, and that all the above-mentioned species belong to the same genus. We therefore propose a revision of the generic formula, protesting, however, against the assertion of the authors last named, that the entire genus *Scaphiocrinus* as formulated by Hall, is identical with *Graphiocrinus*. *Scaphiocrinus simplex*, and a few other species like it with a single anal plate, are undoubtedly so, but all others, and by far the majority of species described under *Scaphiocrinus*, are generically distinct from *Graphiocrinus*, and must be classed with *Poteriocrinus*.

Closely related to *Graphiocrinus* are *Bursacrinus*, Meek & Worthen, and *Phialocrinus*, Trautschold. We can perceive slight structural differences by which the two might be distinguished from the first, but it can only be a subgeneric division, and it is somewhat questionable whether even this can be maintained as to *Phialocrinus*.

Revised Generic Diagnosis.—General form elongate, almost cylindrical. Calyx small, rather shallow, with bilateral symmetry. Underbasals five, minute, rarely extending beyond the column. Basals small; four at least, frequently all five of them, equal. The former is the case in all species in which the anal plate is disconnected from the basals, the latter when it rests directly upon one of them, in which case the posterior basal is considerably higher and truncate above. Radials large, their upper articulating margins straight. Brachials one by five, as large or larger than the radials, and of a similar form, but with the lower margin straight; sutures gaping, articulating facet occupying the entire width of the plate.

There are generally two arms to each brachial, or ten to the individual, which remain simple throughout; but in the above mentioned species the upper side of the brachials is truncate, and the Crinoid has only five arms. The arms are long and heavy, composed of short joints with almost parallel sutures. Pinnulæ long.

A single rather small anal plate is placed half-way between the radials and brachials, either resting on the posterior basal or separated from it, but in either case extending above the plane of the radials. Ventral sac, so far as observed, strong, composed of elongate hexagonal plates. Column round or obtusely pentagonal.

Geological position, etc.—Found so far only in the Subcarboniferous both of Europe and America. We recognize the following species:—

*1861. ? **Graphiocrinus carbonarius** Meek & Worthen. (**Scaphiocr. carbonarius.**) Proc. Acad. Nat. Sci. Phil., p. 140; Geol. Rep. Ill., vol. v. p. 562, pl. 24, fig. 2. Coal Measures. Springfield, Ill.

1853. **Graphiocr. encrinoides** De Koninck & Lehon. Type of the genus. Recherch. Crin. Belg., p. 117, pl. 4, fig. 15, 15 a, b. Mountain limest. Subcarb. Tournay, Belg., and Bristol, Eng.

*1873. **Graphiocr. McAdamsi** Worthen. (**Scaphiocr. McAdamsi.**) Geol. Rep. Ill., vol. v. p. 495, pl. 15, fig. 2. Keokuk limest. Subcarb. Jersey Co., Ill.

*1869. **Graphiocr. rudis** Meek & Worthen. (**Scaphiocr. rudis.**) Proc. Acad. Nat. Sci. Phil., p. 139; Geol. Rep. Ill., vol. v. p. 412, pl. 1, fig. 1. Upper Burlington limest. Subcarb. Burlington, Iowa.

*1858- **Graphiocr. simplex** Hall. (**Scaphiocr. simplex.**) Geol. Rep. Iowa, vol. i. pt. ii. p. 551, pl. 9, Fig. 10. Burlington limest. Subcarb. Burlington, Iowa.

*1861. **Graphiocr. spinobrachiatus** Hall. (**Scaphiocr. spinobrachiatus.**) New Pal. Crin., p. 8; Bost. Journ. Nat. Hist., p. 306. Lower Burlington limest. Subcarb. Burlington, Iowa.

*1869. **Graphiocr. striatus** Meek & Worthen. (**Scaphiocr. striatus.**) Proc. Acad. Nat. Sci. Phil., p. 142; Geol. Rep. Ill., vol. v. pl. 2, fig. 11. Lower Burlington limest. Subcarb. Burlington, Iowa.

*1861. **Graphiocr. tortuosus** Hall. (**Scaphiocr. tortuosus.**) Desc. New Pal. Crin., p. 7; Bost. Journ. Nat. Hist., p. 309. Upper and Lower Burlington limest. Subcarb. Burlington, Iowa.

*1861. **Graphiocr. Wachsmuthi** Meek & Worthen. (**Scaphiocr. Wachsmuthi.**) Proc. Acad. Nat. Sci. Phil., p. 141; Geol. Rep. Ill., vol. iii., p. 488, pl. 16, fig. 7, a, b. Lower Burl. limest. Subcarb. Burlington, Iowa.

B. Subgenus BURSACRINUS Meek & Worthen.

1861. *Bursacrinus* M. & W. Proc. Acad. Nat. Sci. Phil., p. 136.
1862. *Bursacrinus* White. Proc. Bost. Soc. Nat. Hist., vol. ix. p. 11.
1868. *Bursacrinus* M. & W. Geol. Rep. Ill., vol. iii. p. 478.

Body rapidly spreading to the top of the first division of the arms. Calyx, in the known species, small and turbinate, closely agreeing with *Graphiocrinus* in its general construction, but the basals comparatively larger, the posterior one much higher and truncated. Radials and brachials smaller, and the single anal plate, which here also reaches beyond the plane of the radials, extends—at least in the typical species—as far as to the lower portion of the first arm plates. The best distinction, however, and that by which *Bursacrinus* is easily recognized, is found in the arms, which are branching instead of simple, broad, flat, and in contact laterally. Between the first bifurcation of the rays on the brachial pieces and the next division above, the arms are very wide, flat, and composed of from six to eight short wedge-form pieces which are squarely truncated on each side. In the division above, the arm pieces are less than half the width of the last, and like all others composed of a single series of joints.

In the extraordinary width of the lower portion of the arms, the flatness of the arm pieces, and the fact that these lie side by side, abutting laterally, *Bursacrinus* somewhat resembles *Ichthyocrinus*, but the arms are comparatively longer and the general construction of the body otherwise is very distinct.

Only two species are known; both are from the Subcarboniferous.

1861. **Bursacrinus Wachsmuthi** Meek & Worthen. Type of the subgenus. Proc. Acad. Nat. Sci. Phil., p. 137; Geol. Rep. Ill., vol. iii. p. 479, pl. 17, fig. 6. Upper Burlington limest. Subcarb. Burlington, Iowa.

1862. **Bursacrinus confirmatus** White. Proc. Bost. Soc. Nat. Hist., vol. ix. p. 11. Lower Burlington limest. Subcarb. Burlington, Iowa.

C. Subgenus (?) PHIALOCRINUS Trautschold.[1] (Not Eichwald)

1879. Monogr. Kalkbrüche von Mjatschkowa, p. 122.

Prof. Trautschold proposed the above name in a full generic sense for two species of Crinoids from the Upper Subcarboniferous of Russia. The resemblance to *Graphiocrinus*, as already mentioned, is so close that we doubt whether the group can be upheld even subgenerically. So far as known, *Phialocrinus patens* differs from *Graphiocrinus*, as now revised, only in having two brachial pieces instead of one, and in the underbasals, which here project slightly beyond the column. The latter is unimportant, and a comparison will show that the two brachials combined have exactly the form of the single plate in *Graphiocrinus;* their division involves no structural change, but merely facilitates articulation. Trautschold's first species only can be placed here: his *P. urna* is certainly a *Poteriocrinus*, as indicated by its obconical form, the large underbasals, and especially by the arrangement of its anal plates.

1879. **Graphiocr. (Phialocrinus) patens** Trautschold. Monogr. d. Kalkbrüche von Mjatsch., p. 123, pl. 15, fig. 4. Upper Subcarb. Near Moscow, Russia.

16. WOODOCRINUS De Koninck.

1854. Recherch. Crin. Belgique. Supplement, p. 4.

General form including arms short and robust; calyx depressed, arrangement of the plates in the anal area unsymmetrical.

Underbasals five; small, quadrangular, forming a pentagon with nearly straight sides, slightly concave in the middle. Basals about of equal size, hexagonal, wider than high. Radials pentagonal, wide, and short, broadly truncate above. Brachials one by five, similar in form to the radials, but truncate below instead of above; they support on each upper sloping side an arm which bifurcates on the fourth to the eighth plate above, the branches remaining simple throughout, thus giving four arms to each ray uniformly.

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[1] Eichwald's genus *Phialocrinus* (Lethaea Rossica, i. p. 578, pl. 31, fig. 27) was not defined, being founded on fragmentary pieces of column.

The arms are rather divergent, heavy, rounded on the outside, gently tapering to the tips and terminating in a sharp point. Arm pieces extremely short, their sutures parallel. Pinnulæ long and numerous, directed inward, composed of ten to twelve small joints.

The anal area is remarkable for its great number of pieces, being composed longitudinally of several rows of plates, alternately arranged. The lower and largest plate rests between two basals, one of the upper sides against the right posterior radial, the other against the first anal of the adjoining row. The second anal plate rests upon a basal, and abuts laterally against the left posterior radial. The third anal is placed upon the first, toward the right side of the second, and rests partly against the right posterior radial. The anal area is elliptic in outline, composed of twelve or more plates, only three of which are on a level with the radials. The form of the ventral sac is unknown, but from all appearances it is somewhat balloon-shaped, and does not extend to the top of the arms.

Column rather slender, composed of alternate wider and narrower joints, their diameter increasing from the root up, being largest next to the calyx; central perforation round.

The genus is from the Subcarboniferous, and the only known species is:—

1854. **Woodocrinus macrodactylus** De Koninck. Recherch. Crin. Belg. Supplement, p. 6, pl. 8, figs. 1 a–d. Upper part of Subcarb. Richmond, England.

17. ZEACRINUS Troost.

1850. *Zeacrinus* Troost. Subgenus of *Poteriocrinus*. Cat. Crin. Tenn., p. 62 (without description.)

1858. *Zeacrinus* Hall. Subgenus of *Poteriocrinus*. Geol. Rep. Iowa, vol. i. pl. 2, p. 544.

1860. *Zeacrinus* Meek & Worthen. Subgenus of *Poteriocrinus*. Geol. Rep. Ill., vol. ii. p. 186. (Not *Zeacrinus* Schultze. Monog. Echin. Eifel Kalk., p. 38.)

General form of body with arms closed, terete or subcylindrical, often contracted near the arm bases and spreading above; Calyx more or less depressed, low cup or basin-shaped, rarely turbinate, with the basal portion sunken in and forming a deep concavity. Arrangement of plates slightly unsymmetrical.

Underbasals five (abnormally six), small, generally hidden in the central concavity, and covered by the column. Basals five, sometimes nearly equal, but more frequently showing a tendency to irregularity on the posterior side. Radials five, pentagonal, the upper side truncate, with a single brachial plate in each of the four lateral rays; the anterior ray, however, as a rule has one, two, to six or more additional quadrangular brachials, and a bifurcating plate above, resembling in outline the single brachial of the other rays. The latter plate is wide, rather short, and of the form of the radials, but truncate below, and joining the entire upper margin of the radial.

Arms comparatively short, bifurcating, scarcely rounded on the exterior, rarely angular; the bifurcating plates comparatively larger and sometimes nodose. Ramifications only occur on the two outer arms of the rays, and these arms have straight outer margins throughout their length. The branches are given off at regular intervals toward the inner side of the ray, and remain single throughout. The arms are all of uniform thickness, and their sides are sharply defined, and when closed they join so neatly with each other that it appears as if they formed a solid body. Arm-joints much wider than long, with nearly parallel sutures. Pinnulæ short and slender, composed of six or more angular joints directed to the interior of the crinoid, not given off laterally. Arm furrows apparently covered by the infolding of the pinnulæ, not by alternating plates.

There are from five to seven anal plates, alternately arranged in two rows, the lower plate resting with one side against the sloping right side of the posterior basal, the other against the right posterior radial, in some species almost touching the underbasals. The arrangement of the succeeding plates is very similar to that of *Woodocrinus*, except that the portion of the anal area above the line of the radials has a sharp triangular outline instead of elliptic as in that genus. The whole protrudes and is almost even with the surface of the adjoining arms, which curve around it or rest upon its flanks. The ventral sac is broadly balloon-shaped, and extends, so far as observed, to about one-half the height of the arm. It is composed of a great number of small plates, is subpyramidal, sharply pointed at its upper end. It consists of five diverging spheromeres, the radial portions deeply depressed, the interradial extending outward in sharp edges, the edge at the posterior side connecting with the anal area, those of the other sides abruptly turned near the top of the calyx toward the posterior of the specimen, where the sac evidently connects with the main body, thus resembling a balloon. The sharp edges are wedged in for a short distance between the outer arms of two different rays, and the arms themselves with their pinnulæ rest within the radial excavations almost as in *Eucalyptocrinus.* The radial spaces are subdivided near their base by a short ridge, underneath which, and apparently independent of the sac, there is seen in every ray a little short tube representing the ambulacral passages. There is no sign of an anal opening, but we have observed two rows of respiratory pores along the median line of the radial depressions.

Column round, sometimes bordered by irregular lateral cirrhi; its diameter small, the central canal minute and apparently round.

The genus *Zeacrinus* is evidently closely related to *Woodocrinus*, and as we are inclined to believe that the ventral sac, which has not yet been discovered in the latter, is most probably similarly constructed, we have felt almost like placing *Zeacrinus* (which was defined as late as 1858 by Hall), under De Koninck's genus as a subgenus. We have noticed, however, a difference in the construction and habitus of the arms by which we think the two may be satisfactorily distinguished. Those of *Woodocrinus*, as observed in a large number of specimens, show a strong inclination to separate by being more or less irregularly bent to one side, particularly near the top; while in *Zeacrinus* they are closely folded up, very much as in *Ichthyocrinus*, and perfectly straight, with quite a different mode of bifurcation. In the former they are round, very robust, terminating in a sharp point; in the latter almost flat, very delicate, and of nearly uniform size throughout.

The identification of *Zeacrinus* has always been attended with difficulty, owing to the fact that it had not been sufficiently well defined. The ventral sac, which really presents the best generic characters, and by which it is easily recognized, was altogether unknown, and the difficulty was increased when several species were admitted which belong to other groups, and which were evidently not intended to be included by the authors of the genus. We have been obliged to throw out all species with long, angular, zigzag arm-joints; these have also a tubular ventral sac, and we have placed them under some of the varieties of *Poteriocrinus*, where they really belong.

Zeacrinus has by most authors been placed under *Poteriocrinus* as a subgenus, but in this we cannot concur. We look upon it rather as the type of an independent little group of Crinoids, including several genera, which culminates in *Hydreionocrinus* and *Cœliocrinus*, some of the last survivors of the Cyathocrinidæ.

Zeacrinus excavatus Schultze is evidently a *Taxocrinus*.

Geological position, etc.—The genus is confined to the Subcarboniferous, ranging through all the divisions of that epoch; and has only been discovered in America.

We recognize the following species:—

1869. **Zeacrinus asper** Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 150. Geol. Rep. Ill., vol. v. p. 430, pl. 1, fig. 7. Lower Burlington limest. (not Upper Burlington l. as stated by M. and W.). Subcarb. Burlington, Iowa.

1859. **Zeacr. bifurcatus** McChesney. New Pal. Foss., p. 10. Trans. Chicago Acad., 1867, vol. i. p. 71, pl. 4, fig. 3. Chester limest. Subcarb. Chester, Ill.

*1862. **Zeacr. bursæformis** White. (**Poteriocr. bursæformis.**) Proc. Bost. Soc. Nat. Hist., p. 10. Lower Burlington limest. Subcarb. Burlington, Iowa.

1873. **Zeacr. compactilis** Worthen. Geol. Rep. Ill., vol. v. p. 536, pl. 21, fig. 5. Subcarb. Cumberland Co., Ky.

1858. **Zeacr. elegans** Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 547, pl. 9, figs. 1 and 2. Upper Burlington limest. Subcarb. Burlington, Iowa.

1847. (?) **Zeacr. florealis** Yandell and Shumard. (**Cyathocr. florealis.**) Cont. Geol. Kentucky, p. 24, pl. 1, fig. 1. Shumard, 1855. *Poteriocr. florealis*, Second Rep. Geol. Missouri, pl. ii. p. 217. Shumard, 1866. *Zeacr. florealis*, Cat. Pal. Foss., pt. i., Echinodermata, p. 399. Chester limest. Subcarb. Grayson Co., Ky.

We are not certain that this species belongs here, as we have never seen the description.

1858. **Zeacr. intermedius** Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 681, pl. 25, fig. 4. Chester limest. Subcarb. Chester, Ill.

1846. **Zeacr. magnoliaeformis** Owen and Norwood. Type of the genus. (**Cyathocr. magnoliaeformis.**) Research Pot. Carb. Rocks, Kentucky. Troost, 1850. *Zeacr. magnoliæformis*, Cat. Crin. Tenn. Hall, 1858, Geol. Rep. Iowa, vol. i. pt. ii. p. 543 and 684, pl. 25, fig. 4. Chester limest. Subcarb. Grayson Co., Ky.

1859. **Zeacr. ovalis** Lyon and Casseday. Am. Jour. Sci. (n. s.) vol. 29, p. 71. Chester limest. Subcarb. Ky.

1858. **Zeacr. ramosus** Hall. Geol. Rep. Iowa, vol. i, pt. ii. p. 548, pl. 9, fig. 3. Upper Burl. limest. Subcarb. Burlington, Iowa.

1869. **Zeacr. scobina** Meek and Worthen. Proc. Acad. Nat. Sci. Phil., p. 149; Geol. Rep. Ill., vol. v. p. 426, pl. 1, fig. 2. Upper Burlington limest. Subcarb. Burlington, Iowa.

1869. **Zeacr. serratus** Meek and Worthen. Proc. Acad. Nat. Sci. Phil., p. 151; Geol. Rep. Ill., vol. v. p. 428, pl. 1, fig. 6. Upper Burlington limest. Subcarb. Burlington, Iowa.

1860. (Sept.) **Zeacr. Troostanus** Meek and Worthen. Proc. Acad. Nat. Sci. Phil., p. 390; Geol. Rep. Ill., vol. ii. p. 186, pl. 16, fig. 2. Upper and Lower Burlington limest. Subcarb. Burlington, Iowa.

(*Syn.*) **Zeacr. scoparius** Hall (Feb. 1861). Descr. New. Pal. Crin., p. 8; Bost. Jour. Nat. Hist., p. 305.

(*Syn.*) **Zeacr. sacculus** White (1862). Proc. Bost. Soc. Nat. Hist., p. 12.

1858. **Zeacr. wortheni** Hall. Geol. Rep. Iowa, vol. i. pt. ii. p. 683. Chester limest. Subcarb. Chester, Ill.

(Compare with *Z. magnoliæformis.*)

18. HYDREIONOCRINUS De Koninck.

1858. Bull. Acad. Royale Belgique, vol. viii. pt. ii. p. 13.

A. Typical form.

General form subcylindrical, short, slightly spreading toward the tips of the arms; with an enormous ventral sac extending beyond the limits of the arms, and covering them like a roof. Calyx short, rounded below, basal portion sometimes deeply concave.

Underbasals small, and, according to De Koninck, forming a five-rayed star or shallow cup. In all known American species the underbasals rest within a deep concavity, and are scarcely visible beyond the column; but they appear to be considerably larger on the interior of the calyx, sometimes almost exceeding the basals in size. Basals five, three of them of equal size, and hexagonal; the two in contact with the anal plates frequently larger. Radials five, large, much wider than high, four of them pentangular, that on the left posterior side quadrangular; the former resting each between two adjacent basals, and the latter abutting upon only one. Brachials one to the ray, or two in the anterior ray, pentangular, as large or larger than the radials, often produced into long spines; in species where the anterior ray has an additional brachial, the first is quadrangular, the second is pentangular and bears the spine. The brachials meet laterally, and support on their upper sloping sides two arms, which subdivide once, or oftener.

The arms ramify in the same manner as in *Zeacrinus*, by throwing off branches toward the inner side of the ray; they touch laterally, and are so arranged that the sutures between the rays, from the basals up, form straight lines, except on the posterior side where the arms curve slightly, following the margin of the anal area. The arms, before they become simple, are composed of short, strongly wedge-shaped joints alternately arranged, which in most species are by degrees turned into a double series of interlocking plates. Pinnulæ very small and short.

The arrangement of the anal plates is exactly as in *Zeacrinus* and *Woodocrinus*, but the anal area is less protuberant. The ventral sac, which is the most remarkable part of this Crinoid, and the best character for distinction, has the form of a mushroom, upright, cylindrical below, abruptly spreading beyond the tips of the arms and forming a rim composed of a row of 6, 11, 15 or more large, spiniferous or nodose plates, spread out horizonally and tending slightly downward. The upper part or roof is low hemispherical, and is formed either by the spiniferous plates themselves, which are in that case unusually large, or more frequently by a number of irregular plates within the centre. The tube, or cylindrical portion of the sac, is composed of small plates, horizontally arranged, and provided at the sutures with one or two rows of respiratory pores. No other aperture has as yet been observed, nor has the connection of the tube with the main body been ascertained.

Column small.

De Koninck, in his generic description, took the upper portion of the ventral sac to be a regular vault, and thereby distinguished this genus from *Poteriocrinus* with a large proboscis, while this organ, as he supposed, was absent in *Hydreionocrinus*. Some of the European species which De Koninck refers to his genus must be considered doubtful until better proof is given that they belong here. His *H. globularis* is, in our opinion, an *Eupachycrinus*.

Hydreionocrinus has the closest relations with *Zeacrinus*, with which it agrees in the construction of the calyx, and in the mode of bifurcation of the arms; but the enormous size of the ventral sac, its peculiar form and construction, seem to warrant a full generic separation.

Geological position, etc.—The genus is known only from the uppermost part of the Subcarboniferous and from the Coal measures, and occurs both in Europe and America.

We recognize the following species:—

*1870. **Hydreionocrinus acanthophorus** Meek and Worthen. (**Zeacr. Hydreionocr. acanthophorus.**) Proc. Acad. Nat. Sci. Phil., p. 28; Geol. Surv. Ill., vol. v. p. 563, pl. 24, fig. 11. Upper Coal Measures. Illinois and Iowa.

*1870. **Hydreionocr. armiger** Meek and Worthen. (**Zeacr.** (?) **armiger.**) Proc. Acad. Nat. Sci. Phil., p. 27; Geol. Rep. Ill., p. 547, pl. 21, fig. 3. Chester limest. Subcarb. Pope Co., Ill.

*1850. **Hydreionocr. depressus** Troost. (**Zeacr. depressus.**) Cat. Pal. Foss. Tenn.; Hall, 1858, Geol. Rep. Iowa, vol. i. pt. ii. p. 546. Chester limest. Subcarb. Kentucky and Alabama.

*1860. **Hydreionocr. discus** Meek and Worthen. (**Zeacr. discus.**) Proc. Acad. Nat. Sci. Phil., p. 390; Geol. Rep. Ill., vol. II. p. 312, pl. 26, figs. 3 a, b. Upper Coal Measures. Illinois.

(Compare with *Hydreionocr. acanthophorus.*)

*1859. **Hydreionocr. mucrospinus** McChesney. (**Zeacr. mucrospinus.**) Desc. New Pal. Foss. p. 10; Trans. Chic. Acad. Sci., 1867, vol. i. p. 7, pl. 4, fig. 7. Coal Measures. Illinois.

1858. **Hydreionocr. woodianus** De Koninck. Type of the genus. Bull. Acad. Royale Belgique, pt. ii. p. 17, pl. 2, figs. 5, 5 a. Subcarboniferous. Richmond, Yorkshire, England.

Doubtful Species, placed under the genus by De Koninck. Bull. Acad. Royale, Belg., vol. iii. pt. ii. p. 13.

1853. (?) **Hydreionocr. calyx** De Koninck and Lehon. (**Zeacr. calyx.**) Recherch. Crin. Carb. Belg., p. 90, pl. 1, fig. 6 a–d. Lower Carboniferous. England and Belgium.

1836. (?) **Hydreionocr. granulosus** Phillips. (**Poteriocr. granulosus.**) Geol. Yorksh., p. 205, pl. 4, fig. 2; Austin, 1843, Mon. Rec. and Foss. Crin., p. 77, pl. 9, figs. 3 a–f. Subcarboniferous. Bolland, England.

1853. (?) **Hydreionocr. McCoyanus** De Koninck and Lehon. (**Poteriocr. McCoyanus.**) Rech. Crin. Carb. Belg., p. 91, pl. 1, fig. 7. Lower Carboniferous. Visé, Belgium.

1853. (?) **Hydreionocr. Phillipsianus** De Koninck and Lehon. (**Poteriocr. Phillipsianus.**) Rech. Crin. Terr. Carb. Belg., p. 91, pl. 1, fig. 7. Lower Carboniferous. Visé, Belgium.

1858. (?) **Hydreionocr. scoticus** De Koninck. Bull. Acad. Royale Belg., vol. iii. pt. ii. p. 19, pl. 2, figs. 6, 7. Carboniferous. Glasgow, Scotland.

B. Subgenus CŒLIOCRINUS White.

1861. *Poteriocrinus* Hall (in part). Bost. Jour. Nat. Hist., p. 300.

1863. *Cœliocrinus* White. Bost. Jour. Nat. Hist., p. 497.

1869. *Cœliocrinus*, subgenus of *Poteriocrinus*, Meek and Worthen. Proc. Acad. Nat. Sci. Phila., p. 138.

When Dr. White proposed the genus *Cœliocrinus*, he had evidently overlooked De Koninck's genus *Hydreionocrinus*, with which it agrees in all essential points except in the form of the ventral sac, which is balloon-shaped in *Cœliocrinus*, instead of like a mushroom, and except also that in *Hydreionocrinus* the calyx is comparatively larger and the arms shorter. Whether these differences are of sufficient importance to justify even a subgeneric division, is to us somewhat doubtful. The two forms are certainly not generically distinct, for they shade into one another so closely that in some species it becomes difficult even to separate them on the above characters. We, for our part, are inclined to recognize in *Cœliocrinus*, which occurs in the lower Subcarboniferous, the earlier stage of *Hydreionocrinus;* the latter, which flourished during the later periods of the Carboniferous, both in Europe and America, representing the culmination of the form in maturity and extravagance, as developed in the course of time. Such extraordinary development in certain parts of the animal—as here in the ventral sac—frequently occurs when a genus is about to become extinct, and *Hydreionocrinus* is, in fact, one of the last survivors of this family. Bearing this in mind, it is of little consequence whether we place the species of this group under *Hydreionocrinus*, or subgenerically under *Cœliocrinus*.

The relations of this form with *Zeacrinus* are also very close and interesting, and the question may well be asked whether all three forms ought not to be placed under *Woodocrinus*, provided this genus possesses an inflated sac, which we consider the most characteristic feature of this little group; especially as they further agree in the shortness of the arms and their peculiar mode of bifurcation. Such a classification would certainly be more natural than to place them under *Poteriocrinus*, as was done by Hall, and subgenerically by Meek and Worthen. All *Poteriocrini* have long arms, and the ventral sac is prolonged into a slender tube. The arms in all species of *Cœliocrinus* are composed of strongly wedge-shaped plates, which almost interlock, as they do completely in most species of *Hydreionocrinus*, while the corresponding joints in *Zeacrinus* and *Woodocrinus* are regularly quadrangular, with parallel sutures.

Geological position, etc.—Found only in the lower part of the Subcarboniferous of America.

The following species may be arranged here, though we rather prefer their consolidation with *Hydreionocrinus.*

1861. **Cœliocrinus dilatatus** Hall. (**Poteriocr. dilatatus**), Descr. New Pal. Crin., p. 6; Bost. Journ. Nat. Hist., p. 300. White, 1863, *Cœliocr. dilatatus*, Bost. Journ. Nat. Hist., p. 501. Lower Burlington limest. Subcarb. Burlington, Iowa.

1873. **Cœliocr. cariniferus** Worthen. (**Zeacr. cariniferus**), Geol. Rep. Illinois, vol. v. p. 535, pl. 20, fig. 4. (?) St. Louis limest. Near Huntsville, Ala.

*1869. **Cœliocr. lyra** Meek and Worthen. (**Zeacr. lyra**), Proceed. Acad. Nat. Sci. Phila., p. 152; Geol. Rep. Illinois, vol. v. p. 432, pl. 1, fig. 11. Upper Burlington limest. Subcarb. Burlington, Iowa.

1863. **Cœliocr. subspinosus** White. Bost. Journ. Nat. Hist., p. 501. Upper Burlington limest. Subcarb. Burlington, Iowa.

1861. **Cœliocr. ventricosus** Hall. (**Poteriocr. ventricosus**), Descr. New Pal. Crin., p. 6; Bost. Journ. Nat. Hist., p. 301. White, 1863, *Cœliocr. ventricosus*, Bost. Journ. Nat. Hist., p. 501. Lower Burlington limest. Subcarb. Burlington, Iowa.

19. EUPACHYCRINUS Meek and Worthen.

1855. *Eupachycrinus*, Proc. Acad. Nat. Sci. Phila., p. 159.

1866. Geol. Rep. Ill., vol. ii., p. 177.

1867. *Cromyocrinus* Trautschold. Crin. jüng. Bergkalkes bei Moskau, p. 19.

1879. *Cromyocrinus*, Monogr. Kalkbrüche von Mjatschkowa, p. 117.

Meek and Worthen proposed the name *Eupachycrinus*, without generic description, for a small group of American Crinoids, which, by their massive, tumid plates, the double series of interlocking plates generally composing the arms, and their general physiognomy, are well distinguished from all other known genera. They made Lyon's *Graphiocrinus quatuor decimbrachialis* the type of the genus, including in it Hall's two species—*Cyathocrinus* (?) *pentalobus* and *Scaphiocrinus orbicularis*, and have since described several new species.

In 1867 Prof. Trautschold, not knowing that such a genus had been established, proposed the name *Cromyocrinus* for two species from the Upper Subcarboniferous of Russia,[1] which in many respects, if not altogether, agree with those upon which *Eupachycrinus* was founded. The species of both agree in the bowl-shaped, sometimes nearly globular form of the calyx, its comparatively very large size, its large and heavy plates, the massive and simple arms, and the exceedingly slender column. A comparison, however, of all the species that have been referred to the two genera discloses the peculiar fact, that some of them disagree in certain other characters which we have heretofore, in connection with other groups, and apparently with good reason, considered to be of generic value. Among these we may mention the variation in the size of the proximal or underbasal plates, in the number and arrangement of the anal pieces, and in the form and arrangement of the arm plates; but to separate them thereby, either under *Cromyocrinus* or otherwise, has so far proved utterly impossible. It is true that the underbasals in all Russian species referred to *Cromyocrinus* are exceptionally large, but only so in the adult stage. In the young specimens, as shown by Trautschold himself, they are so minute as not to extend beyond the column, so that in making the size of these plates a generic character we should be obliged to separate the young and adult.

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[1] We are under obligations to Dr. Trautschold for some excellent Crinoids from the Russian beds, and to Prof. Wetherby, of Cincinnati, for the loan of some rare and well-preserved specimens of *Eupachycrinus.*

There are, moreover, several American species which in all other respects agree with the typical forms of *Cromyocrinus*, but in which these plates, even in the adult, are exceedingly small. The same difficulty is met with in regard to the anal area. In two species—*Eupachycrinus Craigii* Meek and Worthen, and *E. Fayettensis* Worthen—the anal area is composed of a single plate, instead of three, and this even extends partly beyond the line of the radials. That this is not an abnormity, but a constant character in the species, is proved by a number of specimens. In every other group we should not hesitate to establish a new genus on this character alone; but in this case we are convinced that it is only of specific importance, since those species agree in all other respects with Meek and Worthen's typical *Eupachycrinus*. In one specimen of another species, in our collection, only the larger, lower anal plate is absent, but this may be considered as abnormal, for the adjacent basal and radial plates show a very irregular form.

Examining the arms, we find them in two of the Russian species of *Cromyocrinus* composed of narrow, transverse, quadrangular plates; in *C. ornatus*, however, they are of cuneiform pieces which by degrees become interlocking plates. The same diversity in the structure of the arm plates is found among American species, some interlocking almost from the base of the arm, others only at the tips, while still others are constructed of a single series of transverse plates, with parallel sutures, as in the two species of *Cromyocrinus* from Russia. We have an example in a specimen from Kentucky, which we owe to the kindness of Prof. Wetherby, evidently *Eupachycrinus formosus* (*Zeacrinus formosus* Worth.), which in every other respect is so closely allied to *Eupachycrinus spartarius* S. A. Miller (which has two rows of alternating arm-pieces), that the two cannot be separated unless the arms are preserved; while, on the other hand, it is almost identical with Trautschold's *Cromyocrinus geminatus*. This is sufficient to show the impracticability of subdividing *Eupachyocrinus*, and we are forced to consider *Cromyocrinus* as a synonym.

It is certainly pertinent to inquire how it is possible that the same differences in the structure of these Crinoids are in some cases of generic, and in others only of specific importance. We think the question can be answered without much speculating. In a paper, "Transition Forms in Crinoids," Proc. Acad. Nat. Sci. Phila., 1878, p. 224, we have endeavored to prove that extravagant forms are of short duration; that many genera, before they become extinct, attain extreme proportions or become extraordinarily developed in certain parts of the body. Such was the case with *Hydreionocrinus* with regard to the ventral sac, which was developed to its farthest extreme in size and proportions. In *Eupachycrinus* the opposite extreme is reached, the same organ being reduced to almost nothing, making it almost doubtful whether the genus ought to be placed with the *Cyathocrinidæ* at all; although we cannot, with our present knowledge, separate it from this family. This form was one of its very latest representatives, which evidently struggled through under great difficulties, and which by degrees accommodated itself to the great changes which took place about the close of the Carboniferous Age. All the peculiarities which are expressed in the genus, the differentiations which distinguish the species, point toward and foreshadow *Encrinus*. We observe this in the form and construction of the calyx; in the number, size, and arrangement of the arms; in the mode of articulation, and in the general aspect. The two mainly differ in the absence of anal plates in *Encrinus;* but here again we find in the species of *Eupachycrinus*, to which we alluded above and which are restricted to the Coal Measures, the forerunners of *Erisocrinus* and *Stemmatocrinus* of the same horizon, which are the prophetic types, if not congenera, of the

Encrinidæ. All this tends to explain the extraordinary modification of characters that took place within the limits of genera at the close of the Carboniferous Era.

Generic Diagnosis.—Calyx large, saucer or bowl-shaped to subglobose. Plates heavy, convex to tumid, sometimes ornamented, their arrangement unsymmetrical; sutures strongly defined.

Underbasals five, of equal size; generally small and forming a concavity; in European species comparatively larger and slightly convex. Basals large, fully as high as wide, bent upwards so that the lower half of the plates stands almost at right angles to the vertical axis, and forms a part of the basal plane, or is involved in the concavity. Three of the basals are equal, pentagonal in outline; the other two modified to accommodate the anal pieces. Radials scarcely as large as the basals, much wider than high, all pentagonal, the. right posterior plate being, however, generally smaller and of a more irregular form. The upper articulating margin of the plate forms a straight line, perfectly filled by the brachials. Brachials one by five, always large, at least twice as wide as high, and frequently extended into a large spine, projecting laterally. Their outer form is almost quadrangular, although they are usually bifurcating plates. They abut laterally, closing the interradial spaces (except at the anal side) by which they appear as if a part of the calyx.

There are generally two arms to each ray or ten to the individual; sometimes only five, as in *Eupachycrinus simplex* Trautschold. They are strong, scarcely diminishing in size to the extremities, and rounded on the outside. They are variously constructed, either of a single or double series of plates, the former being either short, transverse with straight lines, or cuneiform, becoming by degrees alternately arranged and interlocking. Ambulacral groove wide and deep; Pinnules short and heavy.

Anal plates generally three, rarely one; succeeding plates forming part of the small ventral tube. The lower anal plate is largest, and sometimes attains, for a plate of this kind, unusual dimensions; it is quadrangular in outline, and rests obliquely between the posterior basal and right radial. The second plate, which is next in size and also large, is placed between the first anal and left radial, and above the basal. The third anal is much swollen, and only the lower half of it is included in the calyx. All succeeding plates, which are alternately arranged, decrease in size upward, and form so far as known a small ventral tube, which has been traced to the height of the fourth or fifth arm plate, where it is composed of small, very delicate, hexagonal plates. The anal plates and lower portion of the tube are slightly protuberant, and give to the calyx a somewhat unsymmetrical aspect. In species with a single anal plate in the calyx, which, so far as observed, are altogether confined to the upper Coal measures, the plate is comparatively small, and rests upon the posterior basal and between the adjoining radials. There can be no doubt that this plate is the homologue of the second anal of other species, with which it closely agrees in form and position; and that the first anal plate is here absent, while the third is included in the ventral tube.

Column round and small.

The upper margin of the radials is provided with a rather prominent, narrow, articulating process, occupying the full width of the plate, corresponding to a similar process opposite on the succeeding brachial. A slit-like opening occupies the middle of it to nearly one-third of its length, which penetrates the plates and evidently contained the muscular apparatus. A similar structure is observed between the brachial and the first arm plates. Such linear processes were well adapted to facilitate the opening and closing of the arms. We may further state that in all species the lower portions of the brachials are pushed inward and the plates incline outward, owing to the position of the hinge lines which are close to the inner edge of the margin of the radial, and at the outer edge of the brachial; the outer edge of the margin of the radial is bevelled. By this structure, which gives to the Crinoids of this genus their peculiar subglobose form, the ponderous arms obtained an important support; for when open, the tumid or spiniferous brachials rested firmly upon the protuberant radials, and this explains fully the office of the brachial spines in this and all similar genera. A similar articulation exists between the brachials and arm plates, and also here the sutures are widely gaping.

Geological position, etc.—The genus is known only from the uppermost part of the Subcarboniferous and the Coal measures, reaching its culmination in the latter. It is found both in Europe and America, from Utah to Central Russia.

We recognize the following species:—

1875. **Eupachycrinus Bassetti** Worthen. Geol. Rep. Ill., vol. vi. p. 528, pl. 32, fig. 2. Coal measures. Illinois.

1870. **Eupachycr. Boydii** Meek & Worthen. Proc. Acad. Nat. Sci. Phila., p. 30. Geol. Rep. Ill., vol. v. p. 554, pl. 21, fig. 6. Chester limest. Subcarb. Chester, Ill.

1875. **Eupachycr. Craigii** Worthen. Geol. Rep. Ill., vol. vi. p. 527, pl. 32, fig. 1. Upper Coal measures. Illinois and Iowa.

Syn. Poteriocr. hemisphæricus, Shumard. 1858. Trans. St. Louis Acad. Sci., vol. i. p. 221; also *Scaphiocr. (?) hemisphericus* Meek, 1872. Final Rep. on Nebraska, p. 147, pl. 5, fig. 1. Geol. Rep. Ill., p. 561, pl. 24, fig. 5.

*1870. **Eupachycr. crassus** Meek & Worthen (**Cyathocr. (?)crassus**). Proc. Acad. Nat. Sci. Phila., p. 392. *Zeacr. (?)crassus*, 1866. Geol. Rep. Ill., vol. ii. pl. 26, figs. 2 a, b. Lower Coal measures. Fulton Co., Ill.

1873. **Eupachycr. Fayettensis** Worthen. Geol. Rep. Ill., vol. v. p. 565, pl. 24, fig. 10. Upper Coal measures. Illinois.

*1873. **Eupachycr. formosus** Worthen (**Zeacr. formosus**). Geol. Rep. Ill., vol. v. p. 549, pl. 21, fig. 2. Chester limest. Subcarb. Chester, Ill.

*1867. **Eupachycr. geminatus** Trautschold (**Cromyocr. geminatus**). Crin. jüng. Bergkalkes, p. 25, pl. 4, fig. 6 (not 7 and 8); 1879, Kalkbrüche von Mjatschkowa, p. 120, pl. 14, figs. 5, 6. Upper Subcarboniferous. Near Moscow, Russia.

*1858. **Eupachycr. globularis** De Koninck (**Hydeionocr. (?)globularis**). Bull. Acad. Royale Belg., pt. ii. p. 21, pl. 2, figs. 1-4. Carboniferous. Near Glasgow, Scotland.

*1861. **(?)Eupachycr. orbicularis** Hall (**Scaphiocr. orbicularis**). Bost. Journ. Nat. Hist., p. 311. Keokuk limest. Subcarb. Keokuk, Iowa.

*1879. **Eupachycr. ornatus** Trautschold (**Cromyocr. ornatus**). Kalkbrüche von Mjatschkowa, p. 121, pl. 14, figs. 9, 10. Upper Subcarb. Near Moscow, Russia.

Figured in "Crin. jüng. Bergkalk., pl. 4, figs. 7 and 8," under *C. geminatus.*

1876. **(?)Eupachycr. platybasalis** White. Geol. Unita Mount., p. 108. Lower Aubrey Gr. Utah.

This species is imperfectly known, and very likely belongs to *Hydreionocrinus.*

1857. **Eupachycr. quatuor decimbrachialis** Lyon. Type of this genus. (**Graphiocr. quatuor decimbrachialis**) Geol. Rep. Kentucky, vol. iii. p. 477, pl. 1, figs. 2 a, b. Coal measures. Crittenden Co., Kentucky.

Syn. Cyathocrinus (?)pentalobus, Hall, 1858. Geol. Rep. Iowa, vol. i. pt. ii. p. 687, pl. 25, figs. 5 a, b.

*1861. **Eupachycr. Sangamonensis** Meek & Worthen. (**Cyathocr. (?) Sangamonensis**) Proc. Acad. Nat. Sci. Phila., p. 392. Geol. Rep. Ill., vol. ii. p. 310, pl. 26, fig. 1 a, b. Upper Coal measures. Sangamon Co., Ill.

This species agrees very well with *Eup. globularis*, and with Trautschold's Russian species in the higher and more globose form of the calyx, as in the large size of the underbasals, which are the only characters upon which a separation under *Cromyocrinus* might be based; but in that case what shall be done with *Eup. crassus*, which has the same form and very small underbasals?

*1867. **Eupachycr. simplex** Trautschold. (**Cromyocr. simplex**) Crin. jüng. Bergkalk, p. 19, pl. 3, figs. 1–4; also 1879. Kalkbrüche von Mjatschkowa, p. 117, pl. 14, figs. 6–8. *Cupressocr. nuciformis* Goldfuss. Oryctographia b. Fisher, p. 151, pl. 41, figs. 5, 6; Fisher, *Poteriocr. nuciformis* Lethaea Rossica i., p. 588; also Quenstadt. Petref. Deutschland, iv. p. 543, pl. 109, fig. 6. Upper Subcarb. Near Moscow, Russia.

The small specimens which Trautschold has figured, and considered to be the young of *Cromyocr. simplex*, represent a very distinct species. In a specimen which we recently obtained from Prof. Zittel, the brachials in two rays are preserved, and show plainly that they are bifurcating plates, while *Cr. simplex* has but five arms. The specimen was labelled *Zeacrinus new sp.* We agree with Prof. Zittel that the calyx resembles that genus closely, but we doubt if it has more than ten arms. The length of the brachials and their form point rather to *Poteriocrinus* (*Scytalocrinus*), from which it differs in the shortness of the calyx. It evidently must be arranged with *Pot.* (*Scytalocrinus*)? *maniformis*, or as a transition form of *Eupachycrinus*.

*1867. **Eupachycr. subtumidus** Worthen. (**Zeacr. subtumidus**). Geol. Rep. Ill., vol. v. p. 548, pl. 21, fig. 1. Chester limest. Subcarb. Pope Co., Ill.

1865. **Eupachycr. tuberculatus** Meek & Worthen. (**Erisocr. tuberculatus**) Proc. Acad. Nat. Sci. Phila., p. 150. Geol. Rep. Ill., vol. ii. p. 319. Upper Coal measures. Illinois and Iowa.

*1867. **Eupachycr. verrucosus** White. (**Hydreionocr.** (?)**verrucosus**). Trans. Chic. Acad. Sci., p. 117. Upper Coal measures. Western Iowa.

20. ERISOCRINUS Meek & Worthen.

1864. A Crinoid near *Encrinus moniliformis*. Marcou. Bull. Geol. Soc., France.

1865, March. *Erisocrinus* M. & W. Am. Journ. Sci., 2d ser. vol. xxix. p. 174.

1865, May. *Philocrinus* M. & W. *Ibid.* (not De Koninck, 1863).

1865, August. *Erisocrinus* M. & W. Proc. Acad. Nat. Sci. Phila., p. 149.

A. Typical form.

Comparing the Crinoidal fauna of our Western States and territories, as we find it toward the close of the Carboniferous, with that of the same geological age in Central Russia, it is surprising to find the same generic forms surviving in both countries.

This has been already seen as to *Poteriocrinus* and *Eupachycrinus*, and will be still further proved in *Stemmatocrinus*, which we consider to be the Russian representative of the American genus *Erisocrinus*, although we are obliged to separate them subgenerically. Trautschold describes his genus *Stemmatocrinus* with a single subbasal plate, while in *Erisocrinus* the pelvis is distinctly divided into five pieces. We also observe a difference in the construction of the arms, which in the former are composed of a double series of interlocking plates, while in the two species of *Erisocrinus*, in which the arms have been found, they are composed of single transverse plates. Both species, however, are from the Burlington limestone, and are very small, and it is extremely probable, from analogy with contemporaries, that the arms in the species from the Coal measures, where the genus flourished more abundantly, were, as in *Stemmatocrinus*, composed of interlocking pieces, and that the Burlington species represent the young form. This would make the difference in the underbasals the only visible distinction.

Meek & Worthen, after publishing the description of *Erisocrinus*, were led by its similarity to a genus described by De Koninck under the name *Philocrinus*, from the Subcarboniferous rocks of India, to believe it identical therewith, and ranged their species under it accordingly. Later comparisons, however, led them to reconsider this. They assert that if *Philocrinus* has no subradial plates, then the two genera are clearly distinct; but, if small plates should be discovered within the plates now called basals, they are probably identical. We have never seen specimens, nor even De Koninck's description of *Philocrinus*, and are unable to express any opinion in the matter.

Generic Diagnosis.—Calyx saucer- to cup-shaped; symmetry strictly equilateral. General aspect similar to that of the two preceding genera.

Underbasals very small, forming a pentagonal, flattened, or concave disc or low cup. Basals large, uniformly hexagonal. Radials considerably larger than the basals, pentagonal, much wider than high, upper sides straight. There being no anals, the plates of each order or of each successive ring are of equal size and like form, and alternate regularly with those of successive rows. Brachials one by five, similar in form to the radials, but the lower margins are straight and the upper obtusely angular for the support of the arms. The brachials abut laterally, leaving no space for interradial or anal plates; the hinge line constructed as in *Eupachycrinus*.

Arms two to each ray, strong, and, so far as yet observed, composed of a single series of transversely oblong pieces.

Column round or obscurely pentagonal.

Geological position, etc.—The typical form of this genus has been found only in America, where it is restricted to the Burlington limestone and Coal measures. The two Burlington species are among the rarest Crinoids of that locality, and in the Coal measures perfect calyces are rare, though fragmentary pieces have been found in some localities in great abundance.

The following species are known:—

1869. **Erisocrinus antiquus** Meek and Worthen. Proc. Acad. Nat. Sci. Phil., p. 71; Geol. Rep. Ill., vol. v. p. 447, pl. 2, fig. 3. Lower Burlington limestone. Subcarb. Burlington, Iowa.

1865. **Erisocr. conoideus** Meek and Worthen. Proc. Acad. Nat. Sci. Phil., p. 150; Geol. Rep. Ill., vol. ii. p. 318. Upper Coal Measures. Springfield, Ill.

1865. **Erisocr. typus** Meek and Worthen. Type of the genus. Am. Jour. Sci., 2d ser. vol. xxix p. 174; Geol. Rep. Ill., vol. ii. p. 319; *ibid.* vol. v. pl. 24, fig. 6. Upper Coal Measures. Springfield, Ill.

Syn. Philocrinus pelvis M. and W. Am. Jour. Sci., 1866, p. 350.

Syn. Erisocrinus Nebrascensis M. and W. Am. Jour. Sci. 1865, p. 174.

1869. **Erisocr. Whitei** Meek and Worthen. Proc. Acad. Nat. Sci. Phil., p. 72; Geol. Rep. Ill., vol. v. p. 448, pl. 2, fig. 2. Upper Burlington limestone. Burlington, Iowa.

B. Subgenus **STEMMATOCRINUS** Trautschold.

1867. Crin. d. jüngeren Bergkalkes b. Moskau, p. 28.
1879. Kalkbrüche von Mjatschkowa, p. 125.

Calyx low cup-shaped, truncate below; symmetry equilateral; all the plates of the calyx regularly alternating.

Underbasals represented by a flat disc, which is undivided, regularly pentagonal, and extending considerably beyond the periphery of the column. Basals pentagonal, abruptly bending upward, the lower portion included in the truncate surface, the upper almost vertical. Radials pentangular, twice as wide as high, articulating lines straight and extending the full width of the plate. Brachials one by five, pentagonal, of similar form with the radials; the upper margin obtusely angular, its sloping sides excavated to receive the arms.

First arm plate simple, comparatively large, lower face rounded.

It is succeeded by two rows of regular interlocking plates. The arms are very heavy, rounded on the outside, continuing of the same size to near the top, where they taper to a sharp point. The articulation between the radial and brachial plates is on the same principle as in *Eupachycrinus*. There is a narrow single line across the entire width of the plate, and the outer edges of both plates adjoining it are so strongly bevelled in the typical species, that if the arms were open, nearly one-half of the brachials would rest upon, and be supported by the sloping face of the radials. Column round.

The total absence of anal plates in this and the preceding section of the genus, distinguishes it readily from any other of this family, but at the same time raises a reasonable doubt whether *Erisocrinus* and *Stemmatocrinus* possessed a solid ventral appendage, and, therefore, whether they belong to the Cyathocrinidæ, or even to the Palæocrinoidea. We have, so far, no knowledge whatever of the construction of the actinal or oral side of the body; whether it had an open mouth or was firmly closed by plates or scaly integument; and if it had not been for their marked resemblance to *Eupachycrinus* in which a ventral tube has been observed, and that both were representatives of the same geological age, living under the very same conditions, we should have felt strongly disposed to place the whole genus with *Encrinus*, with which it has, indeed, both in body and arms, the closest affinities. That *Erisocrinus* and *Stemmatocrinus* have only one brachial, and *Encrinus* two, is not material, and is, at the most, only of generic importance; but in *Encrinus* the aboral side of the body, or the plates which in all Cyathocrinidæ constitute the calyx, form almost a flat disc—at least do not extend beyond the basal plane—and this is the only important distinction which can be discovered between the two forms in the fossil state. This, however, may involve important structural modification in the internal anatomy of the animal, and probably shut out *Encrinus* entirely from the Palæocrinoidea.

Geological Position, etc.—Stemmatocrinus is only known from the limestone beds of Mjatschkowa, where Prof. Trautschold discovered the only species.

1867. **Stemmatocrinus cernuus Trautsch.** Bulletin d. l. Soc. d. Nat. de Moscou, 1867; also Monogr. d. Kalkbr. v. Mjatschkowa, 1879, p. 125, pl. 14, fig. 12. Upper part of Subcarbon., near Moscow, Russia.

21. (?) **EUSPIROCRINUS** Angelin.

1878. Iconogr. Crinoid., Suec. p. 24.

General form, including arms, short subcylindrical. Calyx cyathiform, unsymmetrical.

Underbasals five, subequal. Basals five, four of them with acute upper angles; the fifth heptagonal, the upper angle being truncate to meet the second anal, its left upper side resting against the adjoining first radial, the oblique right side against the first anal plate. Radials large, sublunular. Brachials two, wide, very short.

Arms dichotomizing, and on becoming free coiled up spirally inward.

Anal area wide, plates large, alternately arranged as in *Poteriocrinus*. Ventral tube rather slender, and composed of but few exceedingly large plates.

Vault constructed of five large oral plates; the ambulacral furrows, which divide within the disc for the two main divisions of each ray, covered by alternating pieces; the median part of the dome closed by rather large apical dome plates.

Column short, composed of alternately larger and smaller joints; central canal moderately large.

We place the genus *Euspirocrinus* by itself, as it differs from all other Cyathocrinidæ in its peculiar arm structure, in which it somewhat resembles *Edriocrinus* Hall, and the recent genus *Holopus* D'Orb. It also differs in the construction of the ventral sac, which appears like the proboscis of the Actinocrinidæ, except that in *Euspiocrinus* the inner cavity is large. Pores have not been observed.

The only known species is,

1878. **Euspirocrinus spiralis** Angelin. Iconogr. Crin. Suec., p. 24, pl. 4, fig. 7 a–e. Upper Siluria. Gotland, Sweden.

22. **CARABOCRINUS** Billings.

1856. Geol. Surv. Canada, p. 275.
1859. Ibid., Decade iv. p. 30.

Carabocrinus and the three following genera are imperfectly known, and placed here with some doubt; better specimens must be discovered before it can be decided whether they are good genera.

Carabocrinus, in our opinion, is founded upon a malformed or recuperated *Cyathocrinus*. A comparison of the two genera will show that on the anterior side they are perfectly identical; they also agree most remarkably in the form of the calyx, the construction of the oral side, the delicacy of the arms, and their mode of branching. The only difference is said to be in the construction of the anal area, which, according to Billings, is composed of three plates, the lower one resting upon the underbasals, which is in itself an anomaly such as is found in no other genus. But, further, if Billings's interpretation of the plates in question be correct, the anal area in *Carabocrinus* would be directed toward the left side of the specimen, which would be the only exception among the Palæocrinoidea, and there exists in no other group of them a basal (subradial of Billings) which is neither radial nor interradial, and which is disconnected from the radials, as would be the case in this genus. (See Billings's Diagram, Dec. iv. p. 30, and pl. 2, fig. 3 c.) In this specimen, which is the only example in which the anal area has been observed, the small and abnormal so-called subradial and the two anal plates of Billings combined, have almost the form of one of the other basals (subradials) and are but slightly larger, and we think that in the specimen they originally formed a single plate, which was accidentally broken during the life of the animal and afterwards recuperated, leaving marks of fracture which Billings took to be sutures between the plates. Similar cases are frequently met with among fossil crinoids, plates being sometimes broken into a dozen or more pieces, which afterwards reunite, each piece retaining the appearance of a true plate.

Geological position, etc.—Billings recognizes the following species:—

1856. **Carabocrinus radiatus** Billings. Type of the genus, and the only species and specimen in which the anal area has been seen. Geol. Surv. Canada, p. 276; Decade iv. p. 31, pl. 2, fig. 3 a–c. Trenton Limestone, Lower Sil. Ottawa, Canada.

1859. **Carabocr. (?) tuberculatus** Billings. Geol. Surv. Can., Dec. iv. p. 33, pl. 10, figs. 2 a–c. Hudson River Gr. Lower Sil. Anticosti.

1859. **Carabocr. van cortlandti** Billings. Geol. Surv. Can., Dec. iv. p. 32, pl. 2, fig. 4. Trenton Limestone, Lower Sil. Township of McNab, Canada.

23. (?) CYRTIDOCRINUS Angelin.

1878. Iconogr. Crin. Suec., p. 20.

This genus is not only very imperfectly known—a single calyx only having been thus far discovered—but it also deviates so materially from all other Cyathocrinidæ, that we doubt whether it can be properly classed with that family. According to Angelin it has four underbasals, which are small and unequal in size. Basals five, pentagonal or hexagonal. A single anal plate is intercalated between two basals and two radials. Radials five-sided, oblique, clypeiform.

1878. **Cyrtidocrinus facietatus** Angelin. Iconogr. Crin. Suec., p. 20, pl. 21, figs. 13, 14, 14 a. Upper Silur. Gotland, Sweden.

24. (?) PACHYOCRINUS Billings.

1859. Geol. Surv. Canada, Dec. iv. p. 22. (Not *Pachycrinus* Eichwald.)

In the single specimen to which Billings applied the above name, there are five pentagonal plates concealed within the cavity for the attachment of the column, and above and alternating with them five very large, thick plates, which may be either basals or radials. The lower portions of these plates are bent under the body, so as to constitute a broad, rounded, or concave bottom to the cup, which has a width of nine lines at a height of two. At this level the cup is broken off in the specimen.

Billings refers to this genus:—

1859. **Pachyocrinus crassibrachialis** Billings. Geol. Surv. Can., Dec. iv. p. 22, pl. 1, figs. 1 a, b. Chazy Limest. Montreal, Canada.

25. (?) MYELODACTYLUS Hall.

1851. Geol. Rep. New York, Pal., vol. ii. p. 191.
1878. Angelin, Iconogr. Crin. Suec. p. 11.
(*Herpetocrinus* Salter, 1873, Cab. Mus. Camb., p. 118 is synonymous with *Myelodactylus*, according to Angelin.)

Hall proposed the above generic name to characterize some most remarkable fragments, apparently arm pieces of Crinoids, in which, according to his description, "the foramen or medullury canal penetrates the column of joints." No other portion of the animal was known to him.

Angelin, for reasons unknown to us, referred to this genus three species, and gave the following generic descriptions, "General form of the body narrow, elongate; calyx cup-shaped. Basals three; parabasals five, polygonal. Primary radials one, forming a single zone; secondary radials in two series, the upper ones triangular and arm bearing. Interradials (probably anals) two. Arms long, threadlike, dichotomizing several times, composed of single joints. Ventral tube distinct, articulated. Column strong, convoluted, composed of thin joints with numerous articulated cirrhi." He places this genus under his division "Trimera" (along with *Taxocrinus* and *Gissocrinus*), among the Taxocrinidæ.

Comparing Angelin's figures, we find that only his *M. heterocrinus* agrees with the description. His *M. gracilis* has five primary radials, or, as we should say, four brachials; his *M.* (?) *interradialis* three to four, and, contrary to the rule in all Cyathocrinidæ, a number of interradial plates. None of the species, however, exhibit the peculiar arm structure upon which Hall founded the genus; but, on the contrary, the two first-named species at least seem to be devoid of pinnulæ. Angelin figures—pl. 10, fig. 25—an isolated convoluted column with numerous cirrhi, which is said to belong to *M. gracilis*, and it seems that the superficial resemblance of this column to the so-called arms of *Myelodactylus* induced Angelin to adopt Hall's name for his species. We cannot see any propriety in founding genera or species upon mere fragments of arms or column, especially in a case like this, where we are by no means satisfied that Hall's figure represents the column, but rather believe, with him, that they are most probably portions of arms. We have here placed *Myelodactylus* provisionally under the Cyathocrinidæ, because Angelin's first two species undoubtedly belong to that family, though probably to different genera. His *M.* (?) *interradialis*, however, is a representative of an altogether different family. They all differ from the Ichthyocrinidæ in the large underbasals, in the free plates above the first radials, the threadlike arms, and the general physiognomy. So far as we know, the species agree with no established genus, but the figures without descriptions are not sufficient for us to found new genera upon.

Hall places here the following species:—

1851. **Myelodactylus brachiatus** Hall. Geol. Surv. N. Y., Pal., vol. ii. p. 232, pl. 45, fig. 7. Niagara Gr. Upper Sil. Near Lockport, N. Y.

1851. **Myelodactylus convolutus** Geol. Surv., N. Y., Pal., vol. ii. p. 191, pl. 42, figs. 5 a, b, and 6 a–h. Niagara Gr. Upper Sil. Lockport, N. Y.

Angelin's species are the following:—

1878. **Myelodactylus gracilis** Angl. Iconogr. Crin. Suec., p. 11, pl. 10, figs. 28. Upper Silur. Gotland, Sweden.

1878. **Myelodactylus heterocrinus,** Angl. Iconogr. Crin. Suec., p. 11, pl. 10, figs. 24, 25. Upper Silur. Gotland, Sweden.

1878. **Myelodactylus** (?) **interradialis** Angl. Iconogr. Crin. Suec., p. 11, pl. 10, figs. 26, 27. Upper Silur. Gotland, Sweden.

LIST OF SYNONYMS, CORRECTIONS, AND IMPERFECTLY DEFINED SPECIES.

Actinocrinus Miller.

A. arthriticus, Phill., see *Gissocr. arthriticus.*

Adelocrinus Phillips, founded upon fragments of column.

A. hystrix Phill., founded upon fragments of column.

Ataxocrinus Lyon, syn. of *Anomalocr.* M. & W.

Bactocrinites fusiformis Schnur., see *Homocrin. fusiformis.*

Bærocrinus Volborth. syn. of *Hybocrinus* (Zittel).

Barycrinus Wachsmuth.

B. Lyoni (Hall's sp.), see *Vasocr. Lyoni.*

Cladocrinus Austin (not Agassiz), see *Taxocrinus.*

C. brevidactylus Aust., see *Taxocr. brevidactylus.*

C. pentagonus Aust., see *Poteriocr. pentagonus.*

Cleiocrinus Billings

C. grandis Bill., founded on fragments of column.

C. magnificus Bill., founded on fragments of column.

Clidochirus Angl., var. of *Calpiocrinus* Angl.

Cromyocrinus Trautschold, syn. of *Eupachycrinus* M. & W.

C. geminatus Trautsch., see *Eupachycr. geminatus.*

C. ornatus Trautsch., see *Eupachycr. ornatus.*

C. simplex Trautsch., see *Eupachycr. simplex.*

Cupulocrinus d'Orbigny, syn. of *Taxocrinus.*

Cupressocrinus, Goldf.

C. nuciformis Goldf., see *Eupachycr. simplex.*

Cyathocrinus Miller.

C. abbreviatus Miller, insufficiently defined.

C. angulatus M. & W., see *Barycr. angulatus.*

C. arthriticus Phill., see *Gissocr. arthriticus.*

C. bulbosus Hall, see *Arachnocr. bulbosus.*

C. bullatus Hall, see *Barycr. bullatus.*

C. conglobatus Troost. Catalogue name.

C. *cornutus* O. & Shum., see *Barycr. cornutus.*
C. *corrugatus* (?) Troost. Catalogue name.
C. *crassibrachiatus* Hall, see *Barycr. crassibrachiatus.*
C. *crassus* M. & W., see *Eupachycr. crassus.*
C. *crateriformis ?* Catalogue name.
C. *decadactylus* Lyon & C., *Pot.* (*Scytalocr.*) *grandis.*
C. *decaphyllus* Ad. Roemer, founded on fragments of column.
C. *depressus* Troost. Catalogue name.
C. *distans* Phill., founded on fragments of column.
C. *divaricatus* Hall, see *Cyathocr. Iowensis.*
C. *dubius* Münster, not distinctly defined.
C. *ellipticus* Phill., founded on fragments of column.
C. *exilis* Eichw., founded on fragments of column.
C. *florealis* O. & Shum., see *Zeacr. florealis.*
C. *foveolatus*, Eichw., founded on fragments of column.
C. *globosus* Troost. Catalogue name.
C. *Gosæ* Ad. Roemer, imperfect specimen.
C. *gracilis* Troost. Catalogue name.
C. *gracilior* F. Roemer, *Poteriocr. gracilior.*
C. *granulatus* Angl., see *Arachnocr. granulatus.*
C. *granuliferus* Shum. 1852. We have not seen the description.
C. *hexadactylus* Lyon, *see Vasocr. Lyoni.*
C. *Hoveyi* Hall, see *Barycr. Hoveyi.*
C. *inequidactylus* McCoy, see *Poteriocr. inequidactylus.*
C. *inflatus* Troost. Catalogue name.
C. *interbrachiatus* Angl., see *Gnorimocr. Loveni* W. & Spr.
C. *intermedius* Hall, see *Pot.* (*Parisocr.*) *intermedius.*
C. *Kelloggi* White, see *Barycr. Kelloggi.*
C. *læviculus* Lyon, see *Poteriocr. læviculus.*
C. *latus* Hall, see *Barycr. sculptilis.*
C. *Lyoni* Hall, see *Vasocr. Lyoni.*
C. *macrocheirus* McCoy, see *Poteriocr. macrocheirus.*
C. *macrodactylus* Phill., see *Taxocr. macrodactylus.*
C. *macropleurus* Hall, see *Vasocr. macropleurus.*
C. *magister* Hall, see *Barycr. magister.*
C. *magnoliæformis* Norw. & Ow., see *Zeacr. magnoliæformis.*
C. *malvaceus* Hall, see *Cyathocr. Iowensis.*
C. *megastylus* Phill. Fragments of column.
C. *nodulosus* Phill. Fragments of column.
C. *ornatus* Phill., perhaps *Platycrinus ?*
C. *penniger* De Vern. Not seen description.
C. *pentalobus* Hall, see *Eupachycr. quatuordecimbrachiatus.*
C. *pinnatus* Goldf. Cluster of arms of some other genus.
C. *pinnatus* Bronn. Not seen description.
C. *protuberans* Hall, see *Barycr. bullatus.*
C. *pusillus* Hall, see *Lecanocr. pusillus.*
C. *pyriformis* Phill., see *Ichthyocr. pyriformis.*
C. *quinquangularis* Miller, see *Pot.* (*Parisocr.*) *quinquangularis.*
C. *quinquelobus* M. & W., see *Barycr. stellatus.*
C. *rarus* Lyon. Too imperfect for identification.

C. Rhenanus F. Roemer, see *Taxocr. Rhenanus.*
C. robustus Troost. Catalogue name.
C. Roemeri Troost. Catalogue name.
C. rugosus Miller (not Goldf.), is *Crotalocr. rugosus.*
C. Sangamonensis M. & W., see *Eupachycr. Sangamonensis.*
C. scitulus M. & W., see *Barycr. sculptilis.*
C. sculptilis Hall, see *Barycr. sculptilis.*
C. sculptus Troost. Catalogue name.
C. sculptus Lyon, see *Vasocr. sculptus.*
C. solidus Hall see *Barycr. solidus.*
C. spurius Hall, see *Barycr. spurius.*
C. stellatus Hall, see *Barycr. stellatus.*
C. subtumidus M. & W., see *Barycr. subtumidus.*
C. Tennesseeus Troost. Catalogue name.
C. tenuiradiatus Lyon. Insufficiently defined.
C. tesseracontadactylus Salter, *Pionocr. tesseracontadactylus.*
C. thomæ Hall, see *Barycr. thomæ.*
C. tricarinatus Ad. Roemer. Fragments of column.
C. tuberculatus Miller, see *Taxocr. tuberculatus.*
C. tumidus Hall, see *Barycr. tumidus.*
C. valens Lyon, see *Vasocr. valens.*
C. variabilis Phill. Fragments of column.
C. viminalis Hall, syn. of *Cyathocr. Iowensis.*
C. Wachsmuthi M. & W., see *Barycr. Wachsmuthi.*
C. Wortheni Lyon, see *Poteriocr. Wortheni.*

Eisocrinus Meek & Worthen.

E. tuberculatus M. & W., see *Eupachycr. tuberculatus.*

Euryalecrinus Austin, syn. of *Taxocrinus.*

Euryocrinus Phill., see *Ichthyocrinus.*

Forbesiocrinus De Kon. & Leh.

F. asteriæformis Hall, see *Onychocr. asteriæformis.*
F. divaricatus Angl., see *Lithocr. divaricatus.*
F. Giddingei Hall, see *Taxocr. Giddingei.*
F. gracilis Schultze, see *Rhopalocr. gracilis.*
F. juvenis Hall, see *Taxocr. juvenis.*
F. Kelloggi Hall, see *Taxocr. Kelloggi.*
F. lobatus Hall, see *Taxocr. lobatus.*
F. lobatus (var.) *tardus* see *Taxocr. lobatus* (var.) *tardus.*
F. Meeki Hall, see *Taxocr. Meeki.*
F. Milleri Angl., see *Lithocr. Milleri.*
F. Monroensis M. & W., see *Onychocr. Monroensis.*
F. multibrachiatus Lyon & C., see *Taxocr. multibrachiatus.*
F. Norwoodii M. & W., syn. of *Onychocr. exsculptus*, L. & C.
F. nuntius Hall, see *Taxocr. nuntius.*
F. obesus Angl., see *Lithocr. obesus.*
F. ramulosus Lyon & C. (not Hall), see *Onychocr. ramulosus.*
F. ramulosus Hall (not L. & C.), see *Taxocr. ramulosus.*
F. robustus Angl., see *Lithocr. robustus.*
F. spinifer Hall, syn. for *Taxocr. Thiemei.*

F. Shumardianus Hall, see *Taxocr. Shumardianus.*
F. Thiemei Hall, see *Taxocr. Thiemei.*
F. Whitfieldi Hall, see *Taxocr. Whitfieldi.*

Grammocrinus Eichwald. Founded on fragments of column.

G. lineatus Eichw. Columns.
G. clathratus Eichw. Columns.

Graphiocrinus De Kon. & Leh.

G. dactylus Hall, see *Pot.* (*Scytalocr.*) *dactylus.*
G. quatuordecimbrachiatus Lyon, see *Eupachycr. quatuordecimbrachiatus.*

Herpetocrinus Salter, see *Myelodactylus.*

Heterocrinus Hall.

H. canadensis Bill., syn. of *Heterocr. simplex* Hall.
H. crassus M. & W., *Iocr. crassus.*
H. gracilis Hall. Pieces of column.
H. incurvus M. & W., see *Anomalocr. incurvus.*
H. polyxo Hall, syn. of *Iocr. subcrassus.*
H. subcrassus M. & W., *see Iocr. subcrassus.*

Homocrinus Hall.

H. angustatus M. & W., see *Dendrocr. angustatus.*
H. polydactylus Shum. *Dendrocr. polydactylus.*

Hybocrinus Billings.

H. incurvus M. & W., see *Anomalocr. incurvus.*

Hydreionocrinus De Koninck.

H. globularis De Kon., see *Eupachycr. globularis.*
H. verrucosus White, see *Eupachycr. verrucosus.*

Hydriocrinus Trautschold, syn. of *Scaphiocrinus.*

H. pusillus, see *Scaphiocr. pusillus.*

Ichthyocrinus Conrad.

I. lævis Angl. (not Conr.), see *Ichthyocr. Gotlandicus.*
I. tesseracontadactylus D'Orb., see *Pionocr. tesseracontadactylus.*

Isocrinus Phill. (not Von Meyer), see *Taxocrinus.*

Lecanocrinus Hall.

L. elegans Bill. Perhaps *Taxocrinus?*
L. lævis Bill. Too imperfect for identification.
L. macropetalus Angl. (not Hall), see *Anisocr. Angelini.*
L. simplex Hall, see *Ichthyocr. simplex.*

Lecythocrinus Joh. Müller, see *Lecythocrinus* Zittel.

L. eifelensis Müll., see *Lecythocr. briareus* Schultze.

Pachycrinus Eichwald. Fragments of column.

P. notatus Eichw. Fragments of column.

Palæocrinus Billings, syn. for *Cyathocrinus.*

P. angulatus Bill., see *Cyathocr. angulatus.*

- *P. pulchellus* Bill., see *Cyathocr. pulchellus.*
- *P. rhombiferus* Bill., see *Cyathocr. rhombiferus.*
- *P. striatus* Bill., see *Cyathocr. striatus.*

Phialocrinus Eichw. (not Trautsch.). Fragments of column.

- *P. impressus* Eichw. Fragments of column.

Phialocrinus Trautsch. (not Eichw.), subgenus of *Graphiocrinus.*

- *P. urna* Trautsch., see *Poteriocr.* (*Scytalocr.*) *urna.*

Philocrinus De Kon.

- *P. pelvis* M. & W., see *Erisocr. typus,* M. & W.

Poteriocrinus Miller.

- *P. abbreviatus* Aust., see *Taxocr. brevidactylus.*
- *P. alternatus* Hall, see *Dendrocr. alternatus.*
- *P. Barrisi* Hall, see *Cyathocr. Barrisi.*
- *P. bursæformis* White., see *Zeacr. bursæformis.*
- *P. caduceus* Hall, see *Dendrocr. caduceus.*
- *P. calyx* De Kon. & Leh., see *Hydreionocr. calyx.*
- *P. carinatus* M. & W., see *Poteriocr.* (*Pachylocr.*) *liliiformis.*
- *P. casei* Meek, see *Dendrocr. casei.*
- *P. Cincinnatiensis* Meek, see *Dendrocr. Cincinnatiensis.*
- *P. concinnus* M. & W., see *Poteriocr.* (*Pachylocr.*) *concinnus.*
- *P. Coreyi* Worthen, see *Poteriocr.* (*Scytalocr.*) *grandis.*
- *P. corycia* Hall, see *Poteriocr.* (*Scaphiocr.*) *corycia.*
- *P. crassimanus* Eichw. Fragments of column.
- *P. crateriformis* Troost. Catalogue name.
- *P. cultidactylus* Hall, see *Poteriocr.* (*Scaphiocr.*) *cultidactylus.*
- *P. cylindricus* Hall, see *Homocr. cylindricus.*
- *P. dilatatus* Hall (not Schultze), see *Cœliocr. dilatatus.*
- *P. dilatatus* Schultze (not Hall), see *Vasocr. dilatatus.*
- *P. Dudleyensis* Aust., see *Cyathocr. Dudleyensis.*
- *P. Dyeri* Meek, see *Dendrocr. Dyeri.*
- *P. Egertoni* Phill., see *Taxocr. Egertoni.*
- *P. enormis* M. & W., see *Cyathocr. enormis.*
- *P. florealis* Shum., see *Zeacr. florealis.*
- *P. fusiformis* Hall (not Schultze), syn. of *Poteriocr.* (*Scytalocr.*) *macrodactylus.*
- *P. fusiformis* Schultze (not Hall), see *Homocr. fusiformis.*
- *P geometricus* Goldf., see *Cyathocr. geometricus.*
- *P. gracilis* Hall (not McCoy), see *Dendrocr. gracilis.*
- *P. granulosus* Phill., see *Hydreionocr. granulosus?*
- *P. hemisphericus* Müller (not Shum.), syn. of *Cyathocr. geometricus.*
- *P. hemisphericus* Shum. (not Müller), see *Eupachycr. Craigii.*
- *P. Hoveyi* Worthen, syn. of *Poteriocr.* (*Scytalocr.*) *robustus*
- *P. impressus* Richt. & Ung. (not Phill.) Imperfectly defined.
- *P. isacobus* Aust., see *Poteriocr.* (*Scaphiocr.*) *isacobus.*
- *P. Keokuk* Hall, see *Poteriocr.* (*Scaphiocr.*) *Keokuk.*
- *P. longidactylus* Aust., 1843, *Poteriocr.* (*Scaphiocr.*) *longidactylus.*
- *P. longidactylus* Shum. 1855, *Poteriocr.* (*Scaphiocr.*) *Missouriensis.*
- *P. longidactylus* McChesn., 1859, syn. *Poteriocr.* (*Scytalocr.*) *decabrachiatus.*

P. McCoyanus De Kon. & Leh., see *Hydreionocr. McCoyanus*(?)
P. mespiliformis Richt. & Ung. Not sufficiently known.
P. Meekianus Shum., see *Cyathocr. Meekianus.*
P. multiplex Trautsch., see *Poteriocr* (*Scaphiocr*) *multiplex.*
P. municipalis Troost. Catalogue name.
P. nanus Roemer, see *Homocr. nanus*
P. nuciformis Fischer (Goldf.), see *Eupachycr. simplex.*
P. occidentalis O. & Shum., see *Agassizocr. occidentalis.*
P. parvus Hall, see *Homocr. parvus.*
P Phillipsianus De Kon. & Leh., see *Hydreionocr. Phillipsianus.*
P pisiformis Roemer, see *Arachnocr. pisiformis.*
P. posticus Hall, see *Dendrocr. posticus.*
P. proboscidialis Worthen, see *Poteriocr.* (*Scaphiocr.*) *proboscidialis.*
P. Rhenanus Wirtg. & Zeiler, see *Taxocr. Rhenanus.*
P. rhombiferus O. & Shum., see *Barycr. rhombiferus.*
P. solidus M. & W., syn. of *Poteriocr.* (*Scaphiocr*) *æqualis.*
P. spinosus O. & Shum., see *Poteriocr.* (*Scaph.*) *spinosus.*
P. subgracilis D'Orb., see *Dendrocr. gracilis.*
P. subimpressus M. & W., see *Poteriocr.* (*Scaphiocr.*) *subimpressus.*
P. Swallovi M. & W., see *Poteriocr.* (*Scaphiocr.*) *swallovi.*
P. tenuidactylus M. & W., syn. of *Poteriocr.* (*Scaphiocr.*) *tenuidactylus.*
P. tenuissimus Eichw. Fragments of column.
P. tumidus O. & Shum., see *Agassizocr. tumidus.*
P. varians Eichw. Fragments of column.
P. ventricosus Hall, see *Cæliocr. ventricosus.*
P. zeæformis Schultze. Not defined.

Scaphiocrinus Hall. A variety of *Poteriocrinus.*
S. abnormis Worthen, see *Poteriocr.* (*Scytalocr.*) *abnormis.*
S. ægina Hall, see *Poteriocr.* (*Decadocr.*) *aegina.*
S. æqualis Hall, 1861 (not 1859), see *Poteriocr.* (*Pachylocr.*) *subaequalis.*
S. Bayensis M. & W., see *Poteriocr.* (*Decadocr.*) *Bayensis.*
S. carinatus M. & W. (not Hall), see *Poteriocr.* (*Pachylocr.*) *liliiformis.*
S. carbonarius M. & W., see *Graphiocr. carbonarius.*
S. decadactylus Worthen, see *Poteriocr.* (*Scytalocr.*) *grandis* W. & Spr.
S. depressus M. & W., see *Poteriocr.* (*Decadocr.*) *depressus.*
S. fiscellus M. & W., see *Poteriocr.* (*Decadocr.*) *fiscellus.*
S. Halli Hall, see *Poteriocr.* (*Decadocr.*) *Halli.*
S. hemisphericus Shum. (Meek), see *Eupachycr. Craigii.*
S. juvenis M. & W., see *Poteriocr.* (*Decadocr.*) *juvenis.*
S. longidactylus McChesn., see *Poteriocr.* (*Scytalocr.*) *decabrachiatus.*
S. lyriope Hall, see *Poteriocr.* (*Decadocr.*) *lyriope.*
S. macrodactylus M. & W., see *Poteriocr.* (*Scytalocr.*) *macrodactylus.*
S. macropleurus Hall, see *Vasocr. macropleurus.*
S. McAdamsi Worthen, see *Graphiocr. McAdamsi.*
S. notabilis M. & W., see *Poteriocr. notabilis.*
S. orbicularis Hall, *Eupachycr. orbicularis.*
S. rudis M. & W., see *Graphiocr. rudis.*
S. scalaris M. & W., see *Poteriocr.* (*Decadocr.*) *scalaris.*
S. simplex Hall, see *Graphiocr. simplex.*

S. spinobrachiatus Hall, see *Graphiocr. spinobrachiatus.*
S. striatus M. & W., see *Graphiocr. striatus.*
S. subtortuosus Hall, see *Poteriocr. (Decadocr.) subtortuosus.*
S. tortuosus Hall, *Graphiocr. tortuosus.*
S. Wachsmuthi M. & W., see *Graphiocr. Wachsmuthi.*
S. Whitei Hall, see *Poteriocr. Whitei.*

Sphærocrinus Roemer. A variety of *Cyathocrinus.*

Taxocrinus Phillips.

T. Austini Angl., see *Gnorimocr. Austini.*
T. briareus Schultze, see *Cyathocr. briareus.*
T. distensus Angl., see *Gnorimocr. distensus.*
T. excavatus Angl., see *Gnorimocr. excavatus.*
T. expansus Angl., see *Gnorimocr. expansus.*
T. interbrachiatus Angl., see *Gnorimocr. interbrachiatus.*
T. oblongus Angl., see *Gnorimocr. oblongus.*
T. ovalis Angl , see *Gnorimocr. ovalis.*
T. punctatus Angl.,, see *Gnorimocr. punctatus.*
T. polydactylus McCoy, see *Onychocr. polydactylus.*
T. rigens Angl., see *Gnorimocr. rigens.*
T. Salteri Angl., see *Gnorimocr. Salteri.*
T. simplex Salter, see *Pionocr. simplex.*
T. tesseracontadactylus d'Orb., see *Pionocr. tesseracontadactylus.*
T. tubuliferus Angl., see *Gnorimocr. tubuliferus.*

Zeacrinus Troost.

Z. arboreus Worthen, see *Poteriocr. (Pachylocr.) arboreus.*
Z. armiger M. & W., see *Hydreionocr. armiger.*
Z. asper M. & W., see *Poteriocr. (Pachylocr.) asper.*
Z. concinnus M. & W., see *Poteriocr. (Pachylocr.) concinnus.*
Z. depressus Troost., see *Hydreionocr. depressus.*
Z. discus M. & W., see *Hydreionocr. discus.*
Z. excavatus Schultze, see *Gnorimocr. excavatus.*
Z. formosus Worthen, see *Eupachycr. formosus.*
Z. lyra M. & W., see *Cæliocr. lyra.*
Z. maniformis Hall, see *Poteriocr. (Scytalocr.) maniformis.*
Z. merope Hall, see *Poteriocr. (Pachylocr.) merope.*
Z. mucrospinus McChes., see *Hydreionocr. mucrospinus.*
Z. paternus Hall, see *Poteriocr. (Pachylocr.) paternus.*
Z. perangulatus White., see *Poteriocr. (Pachylocr.) perangulatus.*
Z. planobrachiatus M. & W., see *Poteriocr. (Pachylocr.) planobrachiatus.*
Z. sacculus White., syn. of *Zeacr. Troostanus.*
Z. scoparius Hall, see *Zeacr. Troostanus.*
Z. Stimpsoni Lyon, see *Poteriocr. (Decadocr.) Stimpsoni.*
Z. subtumidus Worthen, see *Eupachycr. subtumidus.*

EXPLANATION OF PLATE 15.

Letters referring to all figures on this plate: *u* = underbasals; *b* = basals; *r* = radials; r^1 = primary radials; r^2 = secondary radials; r^3 = tertiary radials; *p* = patelloid plates; *a* = arm plates; *i* = interradials; *d* = axillary plates; *an* = anal plates; *br* = brachial plates; *A* = anterior side; *P* = posterior side.

Fig. 1. Diagram of *Forbesiocrinus*, showing the fundamental arrangement of plates in the Ichthyocrinidæ.

Fig. 2. Diagram of *Taxocrinus*, showing, in connection with Fig. 1, the distinction in the anal side between this genus and *Forbesiocrinus*.

Fig. 3. Diagram of *Barycrinus*, showing the fundamental arrangement of plates in the Cyathocrinidæ.

Fig. 4. Apical plates in *Actinocrinus*.

Fig. 5. Apical plates in *Platycrinus*.

EXPLANATION OF PLATE 16.

Fig. 1. Diagram of *Anomalocrinus*.

Fig. 2. Diagram of *Heterocrinus*.

Fig. 3. Diagram of *Iocrinus*.

This and the following figures on this plate are given to show the development of the anal plates from one genus to another.

Fig. 4. Diagram of *Hybocrinus*.

Fig. 5. Diagram of *Dendrocrinus*.

Fig. 6. Diagram of *Homocrinus*.

Fig. 7. Diagram of *Poteriocrinus*.

Fig. 8. Diagram of *Cyathocrinus*.

EXPLANATION OF PLATE 17.

Fig. 1. Pentacrinoid larva of *Antedon rosacea*. (After Allman.) *s* = stem; *cd* = centrodorsal plate; *b* = basals; *r* = radials; *or* = oral plates.

Fig. 2. Ventral side of *Cyathocrinus*, showing the oral plates, the apical and radial dome plates being removed.

$\frac{d}{or}$ = oral plates—equivalent to *d* in Fig. 4.

Fig. 3. Ventral side of *Cupressocrinus*, showing the hydrospires; *h* = consolidating apparatus of European authors; *g* = openings which, from

their relative position, we suppose may be equivalents of the passage in the inner lancet pieces in *Pentremites*, designated as *l* in Fig. 5.

Fig. 4. Summit of *Pentremites*, showing the deltoid pieces and their appendages—hidden from view by the test in perfect specimens; *a* = anal opening; *h* = hydrospires; *o* = inner wall or floor of the passage (so-called ovarian openings) leading to the hydrospires; the outer wall, which is a part of the pseudambulacrum, having been removed from the specimen; *d* = the outer or visible portion of the deltoid pieces—equivalent to *d* in Fig. 2; *l* = plates lying directly below the lancet piece, with tubular passage running lengthwise through them (see *l* in Fig. 5); *b* = passage formed by the edges of two deltoid pieces and the inner lancet piece, externally covered by the pseudambulacrum—equivalent to the opening at the base of the arms in Paleocrinoids.

This figure is a representative of the structure of this portion of the Blastoid, as ascertained by examination of a number of specimens, some in which parts of the test have been removed, others in form of polished sections. It is based upon observation, not imagination, and this figure, in connection with No. 5, will, we hope, enable the reader to understand a construction always difficult to explain, and which is now, for the first time, correctly figured, as we believe. We have not attempted to illustrate the details upon which our figure is based, because our object at present is only to point out certain affinities between some forms of Palæocrinoidea and the Blastoidea.

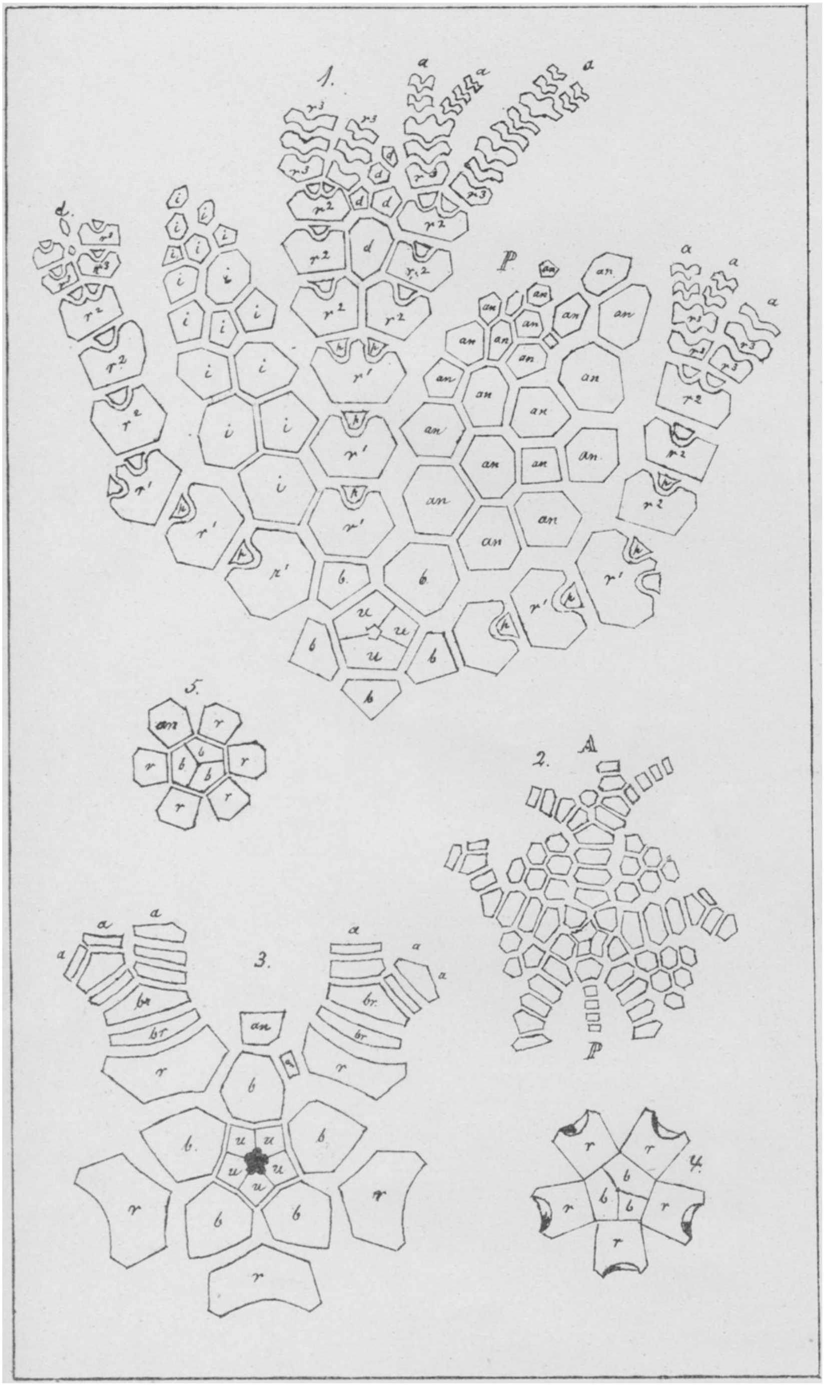
Fig. 5. Cross section of *Pentremites pyriformis* Say (at one-half the height of the ambulacrum, one ray of the latter being removed).

f = the halves of the forked plate; *L* = lancet pieces; *l* = inner lancet pieces; *p* = pore pieces; *m* = ambulacral groove and food passage —covered in perfect specimens; *c* = pores on the ambulacral field.

Figs. 6, 7, 8. Hydrospires of *Caryocrinus ornatus*. 6. Surface view, showing the openings through the test. 7. Representing the course of the flat internal tubes. 8. Transverse section.

(NOTE.—The figures on this plate are more or less enlarged.)

Pl. I.



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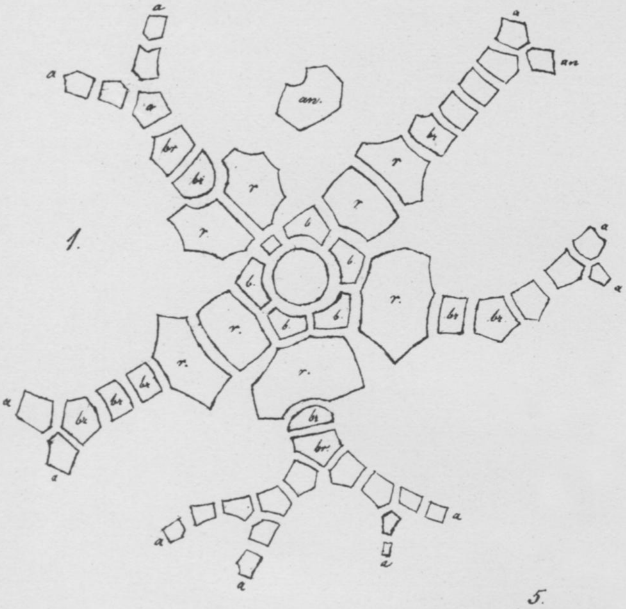
Pl. II.

1.



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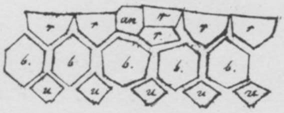

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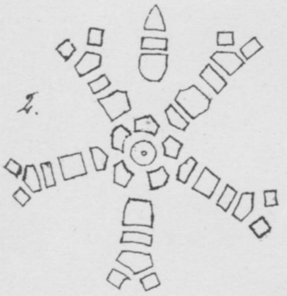

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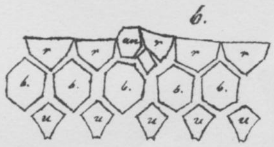

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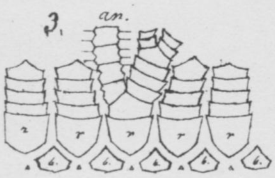

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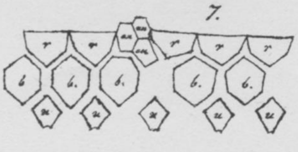

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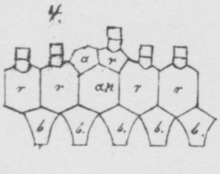

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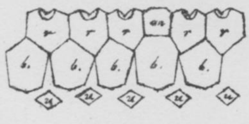

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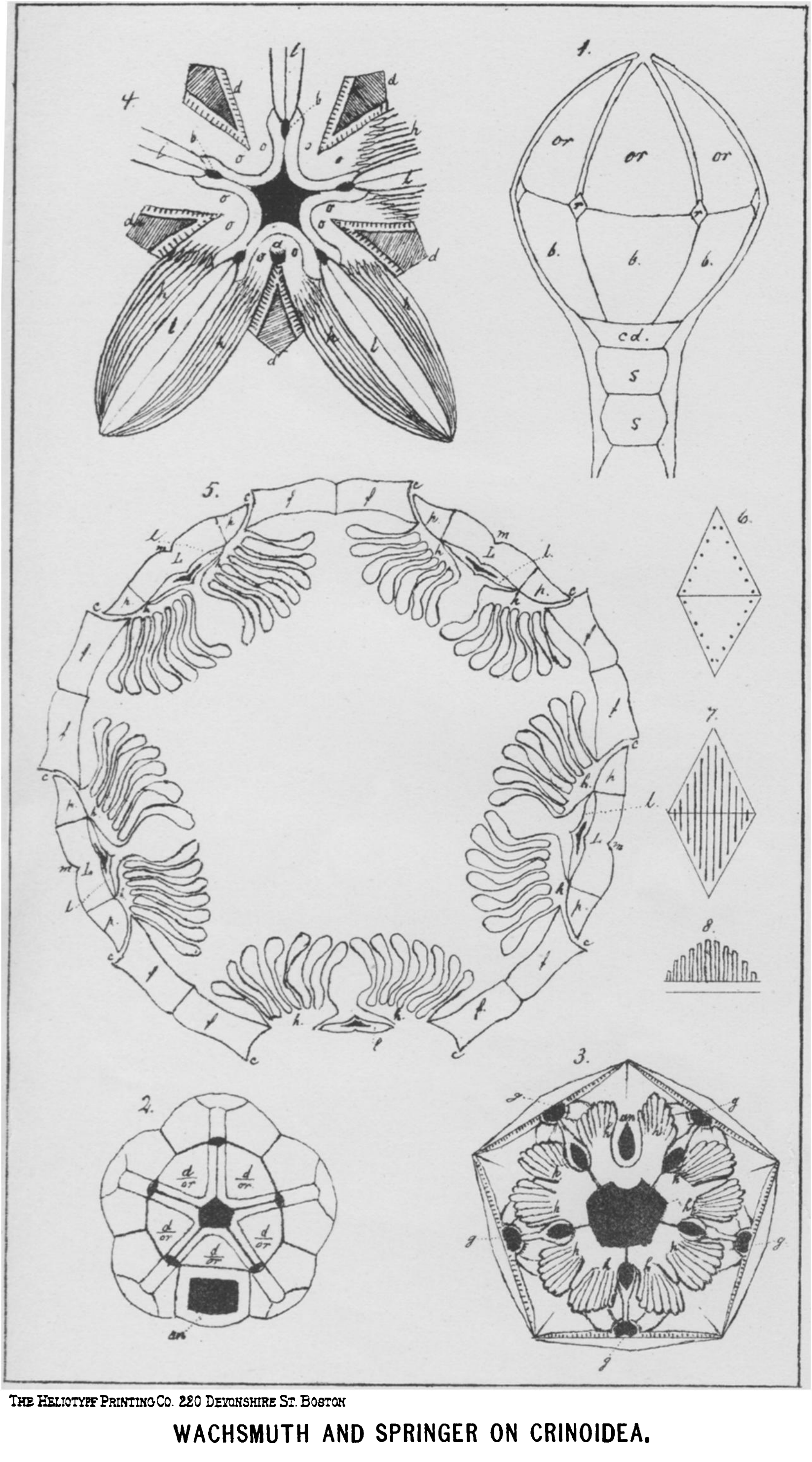

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